# Thorium Aff

## 1AC – Standard

### 1AC – Prolif

#### Nuclear Power multiplies the risk for nuclear proliferation and nuclear terror – safeguards are uncertain and nuclear power weakens them

Miller and Sagan 9 - Steven E. Miller, Director, International Security Program; Editor-in-Chief, International Security; Co-Principal Investigator, Project on Managing the Atom, Scott Sagan, Former Research Fellow, International Security Program, 1981-1982; Editorial Board Member, Quarterly Journal: International Security ("Nuclear Power Without Nuclear Proliferation?" Journal Article, Daedalus, volume 138, issue 4, pages 7-18, <http://belfercenter.hks.harvard.edu/publication/19850/nuclear_power_without_nuclear_proliferation.html>) RMT

Today, the Cold War has disappeared but thousands of those weapons have not. In a strange turn of history, the threat of global nuclear war has gone down, but the risk of a nuclear attack has gone up. More nations have acquired these weapons. Testing has continued. Black market trade in nuclear secrets and nuclear materials abound. The technology to build a bomb has spread. Terrorists are determined to buy, build or steal one. Our efforts to contain these dangers are centered on a global non-proliferation regime, but as more people and nations break the rules, we could reach the point where the center cannot hold.

—President Barack Obama Prague, April 5, 2009

The global nuclear order is changing. Concerns about climate change, the volatility of oil prices, and the security of energy supplies have contributed to a widespread and still-growing interest in the future use of nuclear power. Thirty states operate one or more nuclear power plants today, and according to the International Atomic Energy Agency (IAEA), some 50 others have requested technical assistance from the agency to explore the possibility of developing their own nuclear energy programs. It is certainly not possible to predict precisely how fast and how extensively the expansion of nuclear power will occur. But it does seem probable that in the future there will be more nuclear technology spread across more states than ever before. It will be a different world than the one that has existed in the past.

This surge of interest in nuclear energy — labeled by some proponents as "the renaissance in nuclear power" — is, moreover, occurring simultaneously with mounting concern about the health of the nuclear nonproliferation regime, the regulatory framework that constrains and governs the world's civil and military-related nuclear affairs. The Nuclear Non-Proliferation Treaty (NPT) and related institutions have been taxed by new worries, such as the growth in global terrorism, and have been painfully tested by protracted crises involving nuclear weapons proliferation in North Korea and potentially in Iran. (Indeed, some observers suspect that growing interest in nuclear power in some countries, especially in the Middle East, is not unrelated to Iran's uranium enrichment program and Tehran's movement closer to a nuclear weapons capability.) Confidence in the NPT regime seems to be eroding even as interest in nuclear power is expanding.

This realization raises crucial questions for the future of global security. Will the growth of nuclear power lead to increased risks of nuclear weapons proliferation and nuclear terrorism? Will the nonproliferation regime be adequate to ensure safety and security in a world more widely and heavily invested in nuclear power? The authors in this two-volume (Fall 2009 and Winter 2010) special issue of Dædalus have one simple and clear answer to these questions: It depends.

On what will it depend? Unfortunately, the answer to that question is not so simple and clear, for the technical, economic, and political factors that will determine whether future generations will have more nuclear power without more nuclear proliferation are both exceedingly complex and interrelated. How rapidly and in which countries will new nuclear power plants be built? Will the future expansion of nuclear energy take place primarily in existing nuclear power states or will there be many new entrants to the field? Which countries will possess the facilities for enriching uranium or reprocessing plutonium, technical capabilities that could be used to produce either nuclear fuel for reactors or the materials for nuclear bombs? How can physical protection of nuclear materials from terrorist organizations best be ensured? How can new entrants into nuclear power generation best maintain safety to prevent accidents? The answers to these questions will be critical determinants of the technological dimension of our nuclear future.

The major political factors influencing the future of nuclear weapons are no less complex and no less important. Will Iran acquire nuclear weapons; will North Korea develop more weapons or disarm in the coming decade; how will neighboring states respond? Will the United States and Russia take significant steps toward nuclear disarmament, and if so, will the other nuclear-weapons states follow suit or stand on the sidelines?

The nuclear future will be strongly influenced, too, by the success or failure of efforts to strengthen the international organizations and the set of agreements that comprise the system developed over time to manage global nuclear affairs. Will new international or regional mechanisms be developed to control the front-end (the production of nuclear reactor fuel) and the back-end (the management of spent fuel containing plutonium) of the nuclear fuel cycle? What political agreements and disagreements are likely to emerge between the nuclear-weapons states (NWS) and the non-nuclear-weapons states (NNWS) at the 2010 NPT Review Conference and beyond? What role will crucial actors among the NNWS — Japan, Iran, Brazil, and Egypt, for example — play in determining the global nuclear future? And most broadly, will the nonproliferation regime be supported and strengthened or will it be questioned and weakened? As IAEA Director General Mohamed ElBaradei has emphasized, "The nonproliferation regime is, in many ways, at a critical juncture," and there is a need for a new "overarching multilateral nuclear framework."1 But there is no guarantee that such a framework will emerge, and there is wide doubt that the arrangements of the past will be adequate to manage our nuclear future effectively.

#### Prolif overwhelms incentives for civilian use of nuclear reactors

Li and Yim 13- Mang-Sung Yim is in the Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology, and Jun Li works at UNC Chapel Hill (“Examining relationship between nuclear proliferation and civilian nuclear power development” Progress in Nuclear Energy Volume 66, July 2013, Pages 108–114<http://www.sciencedirect.com/science/article/pii/S0149197013000504>) RMT

This paper attempts to examine the relationship between nuclear weapons proliferation and civilian nuclear power development based on the history of Atoms for Peace Initiative. To investigate the relationship, a database was established by compiling information on a country's civilian nuclear power development and various national capabilities and situational factors. The results of correlation analysis indicated that the initial motivation to develop civilian nuclear power could be mostly dual purpose. However, for a civilian nuclear power program to be ultimately successful, the study finds the role of nuclear nonproliferation very important. The analysis indicated that the presence of nuclear weapons in a country and serious interest in nuclear weapons have a negative effect on the civilian nuclear power program. The study showed the importance of state level commitment to nuclear nonproliferation for the success of civilian nuclear power development. NPT ratification and IAEA safeguards were very important factors in the success of civilian nuclear power development. In addition, for a country's civilian nuclear power development to be successful, the country needs to possess strong economic capability and be well connected to the world economic market through international trade. Mature level of democracy and presence of nuclear technological capabilities were also found to be important for the success of civilian nuclear power program.

#### Prolif in new states causes nuclear conflict.

Kroenig 14 – Matthew, Associate Professor and International Relations Field Chair at Georgetown University, and Nonresident Senior Fellow in the Brent Scowcroft Center on International Security at The Atlantic Council (“The History of Proliferation Optimism: Does It Have A Future?”, April 2014, http://www.matthewkroenig.com/The%20History%20of%20Proliferation%20Optimism\_Feb2014.pdf)

The spread of nuclear weapons poses a number of severe threats to international peace and security including: nuclear war, nuclear terrorism, global and regional instability, constrained freedom of action, weakened alliances, and further nuclear proliferation. Each of these threats has received extensive treatment elsewhere and this review is not intended to replicate or even necessarily to improve upon these previous efforts. Rather the goals of this section are more modest: to usefully bring together and recap the many reasons why we should be pessimistic about the likely consequences of nuclear proliferation. Many of these threats will be illuminated with a discussion of a case of much contemporary concern: Iran’s advanced nuclear program. Nuclear War. The greatest threat posed by the spread of nuclear weapons is nuclear war. The more states in possession of nuclear weapons, the greater the probability that somewhere, someday, there will be a catastrophic nuclear war. To date, nuclear weapons have only been used in warfare once. In 1945, the United States used nuclear weapons on Hiroshima and Nagasaki, bringing World War II to a close. Many analysts point to the sixty-five-plus-year tradition of nuclear non-use as evidence that nuclear weapons are unusable, but it would be naïve to think that nuclear weapons will never be used again simply because they have not been used for some time. After all, analysts in the 1990s argued that worldwide economic downturns like the great depression were a thing of the past, only to be surprised by the dot-com bubble bursting later in the decade and the Great Recession of the late Naughts.49 This author, for one, would be surprised if nuclear weapons are not used again sometime in his lifetime. Before reaching a state of MAD, new nuclear states go through a transition period in which they lack a secure second-strike capability. In this context, one or both states might believe that it has an incentive to use nuclear weapons first. For example, if Iran acquires nuclear weapons, neither Iran, nor its nuclear-armed rival, Israel, will have a secure, second-strike capability. Even though it is believed to have a large arsenal, given its small size and lack of strategic depth, Israel might not be confident that it could absorb a nuclear strike and respond with a devastating counterstrike. Similarly, Iran might eventually be able to build a large and survivable nuclear arsenal, but, when it first crosses the nuclear threshold, Tehran will have a small and vulnerable nuclear force. In these pre-MAD situations, there are at least three ways that nuclear war could occur. First, the state with the nuclear advantage might believe it has a splendid first strike capability. In a crisis, Israel might, therefore, decide to launch a preventive nuclear strike to disarm Iran’s nuclear capabilities. Indeed, this incentive might be further increased by Israel’s aggressive strategic culture that emphasizes preemptive action. Second, the state with a small and vulnerable nuclear arsenal, in this case Iran, might feel use ‘em or loose ‘em pressures. That is, in a crisis, Iran might decide to strike first rather than risk having its entire nuclear arsenal destroyed. Third, as Thomas Schelling has argued, nuclear war could result due to the reciprocal fear of surprise attack.50 If there are advantages to striking first, one state might start a nuclear war in the belief that war is inevitable and that it would be better to go first than to go second. Fortunately, there is no historic evidence of this dynamic occurring in a nuclear context, but it is still possible. In an Israeli-Iranian crisis, for example, Israel and Iran might both prefer to avoid a nuclear war, but decide to strike first rather than suffer a devastating first attack from an opponent. Even in a world of MAD, however, when both sides have secure, second-strike capabilities, there is still a risk of nuclear war. Rational deterrence theory assumes nuclear-armed states are governed by rational leaders who would not intentionally launch a suicidal nuclear war. This assumption appears to have applied to past and current nuclear powers, but there is no guarantee that it will continue to hold in the future. Iran’s theocratic government, despite its inflammatory rhetoric, has followed a fairly pragmatic foreign policy since 1979, but it contains leaders who hold millenarian religious worldviews and could one day ascend to power. We cannot rule out the possibility that, as nuclear weapons continue to spread, some leader somewhere will choose to launch a nuclear war, knowing full well that it could result in self-destruction. One does not need to resort to irrationality, however, to imagine nuclear war under MAD. Nuclear weapons may deter leaders from intentionally launching full-scale wars, but they do not mean the end of international politics. As was discussed above, nuclear-armed states still have conflicts of interest and leaders still seek to coerce nuclear-armed adversaries. Leaders might, therefore, choose to launch a limited nuclear war.51 This strategy might be especially attractive to states in a position of conventional inferiority that might have an incentive to escalate a crisis quickly. During the Cold War, the United States planned to use nuclear weapons first to stop a Soviet invasion of Western Europe given NATO’s conventional inferiority.52 As Russia’s conventional power has deteriorated since the end of the Cold War, Moscow has come to rely more heavily on nuclear weapons in its military doctrine. Indeed, Russian strategy calls for the use of nuclear weapons early in a conflict (something that most Western strategists would consider to be escalatory) as a way to de-escalate a crisis. Similarly, Pakistan’s military plans for nuclear use in the event of an invasion from conventionally stronger India. And finally, Chinese generals openly talk about the possibility of nuclear use against a U.S. superpower in a possible East Asia contingency. Second, as was also discussed above, leaders can make a “threat that leaves something to chance.”53 They can initiate a nuclear crisis. By playing these risky games of nuclear brinkmanship, states can increases the risk of nuclear war in an attempt to force a less resolved adversary to back down. Historical crises have not resulted in nuclear war, but many of them, including the 1962 Cuban Missile Crisis, have come close. And scholars have documented historical incidents when accidents nearly led to war.54 When we think about future nuclear crisis dyads, such as Iran and Israel, with fewer sources of stability than existed during the Cold War, we can see that there is a real risk that a future crisis could result in a devastating nuclear exchange. Nuclear Terrorism. The spread of nuclear weapons also increases the risk of nuclear terrorism.55 While September 11th was one of the greatest tragedies in American history, it would have been much worse had Osama Bin Laden possessed nuclear weapons. Bin Laden declared it a “religious duty” for Al Qaeda to acquire nuclear weapons and radical clerics have issued fatwas declaring it permissible to use nuclear weapons in Jihad against the West.56 Unlike states, which can be more easily deterred, there is little doubt that if terrorists acquired nuclear weapons, they would use them. Indeed, in recent years, many U.S. politicians and security analysts have argued that nuclear terrorism poses the greatest threat to U.S. national security.57 Analysts have pointed out the tremendous hurdles that terrorists would have to overcome in order to acquire nuclear weapons.58 Nevertheless, as nuclear weapons spread, the possibility that they will eventually fall into terrorist hands increases. States could intentionally transfer nuclear weapons, or the fissile material required to build them, to terrorist groups. There are good reasons why a state might be reluctant to transfer nuclear weapons to terrorists, but, as nuclear weapons spread, the probability that a leader might someday purposely arm a terrorist group increases. Some fear, for example, that Iran, with its close ties to Hamas and Hezbollah, might be at a heightened risk of transferring nuclear weapons to terrorists. Moreover, even if no state would ever intentionally transfer nuclear capabilities to terrorists, a new nuclear state, with underdeveloped security procedures, might be vulnerable to theft, allowing terrorist groups or corrupt or ideologically-motivated insiders to transfer dangerous material to terrorists. There is evidence, for example, that representatives from Pakistan’s atomic energy establishment met with Al Qaeda members to discuss a possible nuclear deal.59 Finally, a nuclear-armed state could collapse, resulting in a breakdown of law and order and a loose nukes problem. U.S. officials are currently very concerned about what would happen to Pakistan’s nuclear weapons if the government were to fall. As nuclear weapons spread, this problem is only further amplified. Iran is a country with a history of revolutions and a government with a tenuous hold on power. The regime change that Washington has long dreamed about in Tehran could actually become a nightmare if a nuclear-armed Iran suffered a break down in authority, forcing us to worry about the fate of Iran’s nuclear arsenal. Regional Instability: The spread of nuclear weapons also emboldens nuclear powers, contributing to regional instability. States that lack nuclear weapons need to fear direct military attack from other states, but states with nuclear weapons can be confident that they can deter an intentional military attack, giving them an incentive to be more aggressive in the conduct of their foreign policy. In this way, nuclear weapons provide a shield under which states can feel free to engage in lower-level aggression. Indeed, international relations theories about the “stability-instability paradox” maintain that stability at the nuclear level contributes to conventional instability.60 Historically, we have seen that the spread of nuclear weapons has emboldened their possessors and contributed to regional instability. Recent scholarly analyses have demonstrated that, after controlling for other relevant factors, nuclear-weapon states are more likely to engage in conflict than nonnuclear-weapon states and that this aggressiveness is more pronounced in new nuclear states that have less experience with nuclear diplomacy.61 Similarly, research on internal decision-making in Pakistan reveals that Pakistani foreign policymakers may have been emboldened by the acquisition of nuclear weapons, which encouraged them to initiate militarized disputes against India.62

#### Weak nuclear states are incentivized to REDUCE checks on nuclear escalation to increase the probability of threats

Powell 15 [Robert Powell (Robson Professor in the Department of Political Science at the University of California, Berkeley.), "Nuclear Brinkmanship, Limited War, and Military Power," International Organization, Summer 2015] AZ

These effects highlight in a very simple way some of the incentives a weak state has to “go nuclear” and thereby be able to transform a contest of strength into one of resolve. If a weak state has no nuclear weapons, it cannot threaten to engage in a process that may ultimately end in its launching a nuclear attack against its adversary. In other words, the potential and minimal risks are zero: ρ(π) = ρ(π)=0 for all π. Absent any risk of escalation, the stronger state brings all of its power to bear (π∗ = π). Nuclear weapons and the latent threat of escalation compel it to bring less power to bear (π <e π). More generally, a militarily weak but resolute state that already has nuclear weapons will be advantaged by a doctrine, posture, and force structure in which the potential risk rises rapidly as more power is brought to bear (a large η). We can see these incentives in the evolution of Pakistan’s nuclear doctrine. In order to deter a militarily stronger adversary from threatening its vital interests, Pakistan, like NATO before it, has eschewed a no-first use nuclear doctrine. After becoming an overt nuclear state in 1998, Pakistan moved toward a nuclear posture which envisioned the possibly rapid, “first use of nuclear weapons against conventional attacks.” This in turned required the operationalization of nuclear weapons as “usable warfighting instruments.”57 As former Pakistani General Feroz Khan puts it, “With relatively smaller conventional forces, and lacking adequate technical means, especially in early warning and surveillance, Pakistan relies on a more proactive nuclear defensive policy.”58 Pakistan’s Ambassador to the United States made the same point in the spring of 2001. Because of the growing conventional asymmetry with India, “Pakistan will be increasingly forced to rely on strategic capabilities... Risks of escalation through accident and miscalculation cannot be discounted.”59 In brief, Pakistan’s nuclear posture, which Narang describes as “asymmetric escalation,” entails a fundamental trade-off. When compared to a posture of “assured retaliation,” which emphasizes survivable second-strike forces targeted against an adversary’s key strategic centers, asymmetric escalation depends on being able to use or credibly threaten to use nuclear weapons against invading conventional forces. However, the forces needed to implement this “can generate severe command and control pressures that increase the risk of inadvertent use of nuclear weapons.”60 Pakistan’s acceptance of a riskier force posture is in keeping with the incentives highlighted in the model. The potential risk of nuclear escalation if India brings a given amount of power to bear is higher if Pakistan has an asymmetric-escalation doctrine. That is, η is higher as illustrated in the shift from η0 to η1 in Figure 6. As a result, India brings less power to bear (πe decreases) and Pakistan is better off (ΩΔ(πe) increases).

### 1AC – Accidents

#### Accidents likely – large releases of radiation are more likely than before

Wheatley et al 16 [Spencer Wheatley (ETH Zurich, Department of Management, Technology and Economics, Switzerland), Benjamin Sovacool, Didier Sornette, "Of Disasters and Dragon Kings: A Statistical Analysis of Nuclear Power Incidents and Accidents," Risk Analysis, March 2016] AZ

Regarding event severity, we found that the distribution of cost underwent a significant regime change shortly after the Three Mile Island major accident. Moderate cost events were suppressed, but extreme ones became more frequent, to the extent that the costs are now well described by the extremely heavy tailed Pareto distribution with parameter inline image. We noted in the introduction that the Three Mile Island accident in 1979 led to plant-specific full-scope control room simulators, plant-specific PSA models for finding and eliminating risks, and new sets of emergency operating instructions. The change of regime that we document here may be the concrete embodiment of these changes catalyzed by the TMI accident. We also identify statistically significant runaway disaster (“dragon-king”) regimes in both NAMS and cost, suggesting that extreme events are amplified to values even larger than those explained under the Pareto distribution with inline image. In view of the extreme risks, the need for better bonding and liability instruments associated with nuclear accident and incident property damage becomes clear. For instance, under the conservative assumption that the cost from Fukushima is the maximum possible, annual accident costs are on par with the construction costs of a single nuclear plant, with the expected annual cost being 1.5 billion USD with a standard deviation of 8 billion USD. If we do not limit the maximum possible cost, then the expected cost under the estimated Pareto model is mathematically infinite. Nuclear reactors are thus assets that can become liabilities in a matter of hours, and it is usually taxpayers, or society at large, that “pays” for these accidents rather than nuclear operators or even electricity consumers. This split of incentives improperly aligns those most responsible for an accident (the principals) from those suffering the cost of nuclear accidents (the agents). One policy suggestion is that we start holding plant operators liable for accident costs through an environmental or accident bonding system,[65] which should work together with an appropriate economic model to incentivize the operators. Third, looking to the future, our analysis suggests that nuclear power has inherent safety risks that will likely recur. With the current model—which does not quantify improvements from the industry response to Fukushima—in terms of costs, there is a 50% chance that (i) a Fukushima event (or larger) occurs in 62 years, and (ii) a TMI event (or larger) occurs in 15 years. Further, smaller but still expensive (⩾20 MM 2013 USD) incidents will occur with a frequency of about one per year, under the assumption of a roughly constant fleet of nuclear plants. To curb these risks of future events would require sweeping changes to the industry, as perhaps triggered by Fukushima, which include refinements to reactor operator training, human factors engineering, radiation protection, and many other areas of nuclear power plant operations. To be effective, any changes need to minimize the risk of extreme disasters. Unfortunately, given the shortage of data, it is too early to judge if the risk of events has significantly improved post-Fukushima. We can only raise attention to the fact that similar sweeping regime changes after both Chernobyl (leading to a decrease in frequency) and Three Mile Island (leading to a suppression of moderate events) failed to mitigate the very heavy tailed distribution of costs documented here.

#### Contamination spreads rapidly – no one is safe

Max - Planck- Gesselschaft 12 –The Max Planck Society for the Advancement of Science is a formally independent non-governmental and non-profit association of German research institute (Max-Planck-Gesellschaft, Major Reactor, 5-22-2012, "Severe nuclear reactor accidents likely every 10 to 20 years, European study suggests," ScienceDaily, https://www.sciencedaily.com/releases/2012/05/120522134942.htm) RMT

25 percent of the radioactive particles are transported further than 2,000 kilometres

Subsequently, the researchers determined the geographic distribution of radioactive gases and particles around a possible accident site using a computer model that describes Earth's atmosphere. The model calculates meteorological conditions and flows, and also accounts for chemical reactions in the atmosphere. The model can compute the global distribution of trace gases, for example, and can also simulate the spreading of radioactive gases and particles. To approximate the radioactive contamination, the researchers calculated how the particles of radioactive caesium-137 (137Cs) disperse in the atmosphere, where they deposit on Earth's surface and in what quantities. The 137Cs isotope is a product of the nuclear fission of uranium. It has a half-life of 30 years and was one of the key elements in the radioactive contamination following the disasters of Chernobyl and Fukushima.

The computer simulations revealed that, on average, only eight percent of the 137Cs particles are expected to deposit within an area of 50 kilometres around the nuclear accident site. Around 50 percent of the particles would be deposited outside a radius of 1,000 kilometres, and around 25 percent would spread even further than 2,000 kilometres. These results underscore that reactor accidents are likely to cause radioactive contamination well beyond national borders.

The results of the dispersion calculations were combined with the likelihood of a nuclear meltdown and the actual density of reactors worldwide to calculate the current risk of radioactive contamination around the world. According to the International Atomic Energy Agency (IAEA), an area with more than 40 kilobecquerels of radioactivity per square meter is defined as contaminated.

The team in Mainz found that in Western Europe, where the density of reactors is particularly high, the contamination by more than 40 kilobecquerels per square meter is expected to occur once in about every 50 years. It appears that citizens in the densely populated southwestern part of Germany run the worldwide highest risk of radioactive contamination, associated with the numerous nuclear power plants situated near the borders between France, Belgium and Germany, and the dominant westerly wind direction.

If a single nuclear meltdown were to occur in Western Europe, around 28 million people on average would be affected by contamination of more than 40 kilobecquerels per square meter. This figure is even higher in southern Asia, due to the dense populations. A major nuclear accident there would affect around 34 million people, while in the eastern USA and in East Asia this would be 14 to 21 million people.

"Germany's exit from the nuclear energy program will reduce the national risk of radioactive contamination. However, an even stronger reduction would result if Germany's neighbours were to switch off their reactors," says Jos Lelieveld. "Not only do we need an in-depth and public analysis of the actual risks of nuclear accidents. In light of our findings I believe an internationally coordinated phasing out of nuclear energy should also be considered ," adds the atmospheric chemist.

#### It’s the single greatest danger to the environment

Stapleton 9 - Richard M Stapleton Is the author of books such as Lead Is a Silent Hazard, writes for pollution issues (“Disasters: Nuclear Accidents” <http://www.pollutionissues.com/Co-Ea/Disasters-Nuclear-Accidents.html>) RMT

Of all the environmental disaster events that humans are capable of causing, nuclear disasters have the greatest damage potential. The radiation release associated with a nuclear disaster poses significant acute and chronic risks in the immediate environs and chronic risk over a wide geographic area. Radioactive contamination, which typically becomes airborne, is long-lived, with half-lives guaranteeing contamination for hundreds of years.

Concerns over potential nuclear disasters center on nuclear reactors, typically those used to generate electric power. Other concerns involve the transport of nuclear waste and the temporary storage of spent radioactive fuel at nuclear power plants. The fear that terrorists would target a radiation source or create a "dirty bomb" capable of dispersing radiation over a populated area was added to these concerns following the 2001 terrorist attacks on New York City and Washington, D.C.

Radioactive emissions of particular concern include strontium-90 and cesium-137, both having thirty-year-plus half-lives, and iodine-131, having a short half-life of eight days but known to cause thyroid cancer. In addition to being highly radioactive, cesium-137 is mistaken for potassium by living organisms. This means that it is passed on up the food chain and bioaccumulated by that process. Strontium-90 mimics the properties of calcium and is deposited in bones where it may either cause cancer or damage bone marrow cells.

#### Biodiversity loss risks extinction - ecosystems aren’t resilient or redundant

Vule 13-School of Biological Sciences, Louisiana Tech University (Jeffrey V. Yule \*, Robert J. Fournier and Patrick L. Hindmarsh, “Biodiversity, Extinction, and Humanity’s Future: The Ecological and Evolutionary Consequences of Human Population and Resource Use”, 2 April 2013, manities 2013, 2, 147–159) RMT

Ecologists recognize that the particulars of the relationship between biodiversity and community resilience in the face of disturbance (a broad range of phenomena including anything from drought, fire, and volcanic eruption to species introductions or removals) depend on context [16,17]. Sometimes disturbed communities return relatively readily to pre-disturbance conditions; sometimes they do not. However, accepting as a general truism that biodiversity is an ecological stabilizer is sensible— roughly equivalent to viewing seatbelt use as a good idea: although seatbelts increase the risk of injury in a small minority of car accidents, their use overwhelmingly reduces risk. As humans continue to modify natural environments, we may be reducing their ability to return to pre-disturbance conditions. The concern is not merely academic. Communities provide the ecosystem services on which both human and nonhuman life depends, including the cycling of carbon dioxide and oxygen by photosynthetic organisms, nitrogen fixation and the filtration of water by microbes, and pollination by insects. If disturbances alter communities to the extent that they can no longer provide these crucial services, extinctions (including, possibly, our own) become more likely. In ecology as in science in general, absolutes are rare. Science deals mainly in probabilities, in large part because it attempts to address the universe’s abundant uncertainties. Species-rich, diverse communities characterized by large numbers of multi-species interactions are not immune to being pushed from one relatively stable state characterized by particular species and interactions to other, quite different states in which formerly abundant species are entirely or nearly entirely absent. Nonetheless, in speciose communities, the removal of any single species is less likely to result in radical change. That said, there are no guarantees that the removal of even a single species from a biodiverse community will not have significant, completely unforeseen consequences.

Indirect interactions can be unexpectedly important to community structure and, historically, have been difficult to observe until some form of disturbance (especially the introduction or elimination of a species) occurs. Experiments have revealed how the presence of predators can increase the diversity of prey species in communities, as when predators of a superior competitor among prey species will allow inferior competing prey species to persist [18]. Predators can have even more dramatic effects on communities. The presence or absence of sea otters determines whether inshore areas are characterized by diverse kelp forest communities or an alternative stable state of species poor urchin barrens [19]. In the latter case, the absence of otters leaves urchin populations unchecked to overgraze kelp forests, eliminating a habitat feature that supports a wide range of species across a variety of age classes.

Aldo Leopold observed that when trying to determine how a device works by tinkering with it, the first rule of doing the job intelligently is to save all the parts [20]. The extinctions that humans have caused certainly represent a significant problem, but there is an additional difficulty with human investigations of and impacts on ecological and evolutionary processes. Often, our tinkering is unintentional and, as a result, recklessly ignores the necessity of caution. Following the logic inherited from Newtonian physics, humans expect single actions to have single effects. Desiring more game species, for instance, humans typically hunt predators (in North America, for instance, extirpating wolves so as to be able to have more deer or elk for themselves). Yet removing or adding predators has far reaching effects. Wolf removal has led to prey overpopulation, plant over browsing, and erosion [21]. After wolves were removed from Yellowstone National Park, the K of elk increased. This allowed for a shift in elk feeding patterns that left fewer trees alongside rivers, thus leaving less food for beaver and, consequently, fewer beaver dams and less wetland [22,23]. Such a situation represents, in microcosm, the inherent risk of allowing for the erosion of species diversity. In addition to providing habitat for a wide variety of species, wetlands serve as natural water purification systems. Although the Yellowstone region might not need that particular ecosystem service as much as other parts of the world, freshwater resources and wetlands are threatened globally, and the same logic of reduced biodiversity equating to reduced ecosystem services applies.

Humans take actions without considering that when tugging on single threads, they unavoidably affect adjacent areas of the tapestry. While human population and per capita resource use remain high, so does the probability of ongoing biodiversity loss. At the very least, in the future people will have an even more skewed perspective than we do about what constitutes a diverse community. In that regard, future generations will be even more ignorant than we are. Of course, we also experience that shifting baseline perspective on biodiversity and population sizes, failing to recognize how much is missing from the world because we are unaware of what past generations saw [11]. But the consequences of diminished biodiversity might be more profound for humans than that. If the disturbance of communities and ecosystems results in species losses that reduce the availability of ecosystem services, human K and, sooner or later, human N will be reduced.

### 1AC – Plan

#### Countries ought to prohibit the production of nuclear power by reactors powered by uranium-235.

#### The plan shifts to thorium-powered reactors – improves energy efficiency and safety and prevents prolif

Halper 13 [Mark Halper, "Hans Blix: Shift to thorium, minimize weapons risk," The Alvin Weinberg Foundation, 10/29/2013] AZ

Hans Blix, the disarmament advocate who famously found no weapons of mass destruction in Iraq a decade ago, said today that thorium fuel could help reduce the risk of weapons proliferation from nuclear reactors. Addressing the Thorium Energy Conference 2013 here, Blix said that nuclear power operators should move away from their time-honoured practice of using uranium fuel with its links to potential nuclear weapons fabrication via both the uranium enrichment process and uranium’s plutonium waste. “Even though designers and operators are by no means at the end of the uranium road, it is desirable today, I am convinced, that the designers and the others use their skill and imagination to explore and test other avenues as well,” Blix said. “The propeller plane that served us long and still serves us gave way to the jet plane that now dominates,” said the former United Nations chief weapons inspector who also ran the International Atomic Energy Agency from 1981 to 1997. “Diesel engines have migrated from their traditional home in trucks to a growing number of cars and cars with electric engines are now entering the market. Nuclear power should also not be stuck in one box.” Blix rattled off a list of thorium’s advantages, noting that “thorium fuel gives rise to waste that is smaller in volume, less toxic and much less long lived than the wastes that result from uranium fuel.” Another bonus: thorium is three to four times more plentiful than uranium, he noted. “The civilian nuclear community must do what it can to help reduce the risk that more nuclear weapons are made from uranium or plutonium,” Blix said. “Although it is enrichment plants and plutonium producing installations rather than power reactors that are key concerns, this community, this nuclear community, can and should use its considerable brain power to design reactors that can be easily safeguarded and fuel and supply organizations that do not lend themselves to proliferation. I think in these regards the thorium community may have very important contributions to make.” Blix described the obstacles that are in the way of a shift to thorium and other nuclear alternatives as “political” rather than “technical.”

#### Uranium is far inferior to thorium but only exists because gov'ts want to proliferate

Katusa 12 [Marin Katusa (Forbes contributor, founder of Katusa Research, financial and energy consultant), "The Thing About Thorium: Why The Better Nuclear Fuel May Not Get A Chance," Forbes Magazine, 2/16/2012] AZ

The Fukushima disaster reminded us all of the dangers inherent in uranium-fueled nuclear reactors. Fresh news this month about Tepco’s continued struggle to contain and cool the fuel rods highlights just how energetic uranium fission reactions are and how challenging to control. Of course, that level of energy is exactly why we use nuclear energy – it is incredibly efficient as a source of power, and it creates very few emissions and carries a laudable safety record to boot. This conversation – “nuclear good but uranium dangerous” – regularly leads to a very good question: what about thorium? Thorium sits two spots left of uranium on the periodic table, in the same row or series. Elements in the same series share characteristics. With uranium and thorium, the key similarity is that both can absorb neutrons and transmute into fissile elements. That means thorium could be used to fuel nuclear reactors, just like uranium. And as proponents of the underdog fuel will happily tell you, thorium is more abundant in nature than uranium, is not fissile on its own (which means reactions can be stopped when necessary), produces waste products that are less radioactive, and generates more energy per ton. So why on earth are we using uranium? As you may recall, research into the mechanization of nuclear reactions was initially driven not by the desire to make energy, but by the desire to make bombs. The $2 billion Manhattan Project that produced the atomic bomb sparked a worldwide surge in nuclear research, most of it funded by governments embroiled in the Cold War. And here we come to it: Thorium reactors do not produce plutonium, which is what you need to make a nuke. How ironic. The fact that thorium reactors could not produce fuel for nuclear weapons meant the better reactor fuel got short shrift, yet today we would love to be able to clearly differentiate a country’s nuclear reactors from its weapons program.

## 1AC Modules

### 1AC – Mining

#### Uranium mining causes disease, pollution, and unclean water, especially in developing countries

Thorpe 8 [David Thorpe (freelance environmental journalist and a news editor for Defra's Energy, Resource, Sustainable and Environmental Management magazine), "Extracting a disaster," The Guardian, 12/5/2008] AZ

2The increased sourcing of raw uranium that will arise from nuclear new build is an ethical and environmental nightmare currently being ignored by the government. The World Nuclear Association (WNA), the trade body for companies that make up 90% of the industry, admits that in "emerging uranium producing countries" there is frequently no adequate environmental health and safety legislation, let alone monitoring. It is considerately proposing a Charter of Ethics containing principles of uranium stewardship for its members to follow. But this is a self-policing voluntary arrangement. Similarly, the International Atomic Energy Agency's safety guide to the Management of Radioactive Waste from the Mining and Milling of Ores (pdf) are not legally binding on operators. The problem is that transparency is not a value enshrined in the extractive or the nuclear industries. Journalists find themselves blocked. Recently, to tackle this issue, Panos Institute West Africa (IPAO) held a training seminar for journalists in Senegal which highlighted that only persistent investigation – or, in the case of the Niger's Tuareg, violent rebellion – has a chance of uncovering the truth. The co-editor of the Republican in Niger, Ousseini Issa, said that only due to local media campaigns was there a revision of the contract linking Niger to the French company Areva. "As a result of our efforts, the price of a kilogram of uranium increased from 25,000 to 40,000 CFA francs," he said. The local community hopes now to see more of the income from the extraction of its resources. IPAO has much evidence that in Africa the legacy of mining is often terrible health, water contamination and other pollution problems. IPAO would laugh at the Extractive Industries Transparency Initiative – an Orwellian creation launched by Tony Blair in 2001. What is the effect of uranium mining? Nuclear fuel from fresh uranium is cheaper than from recycled uranium or recycled plutonium (MOX), which is why there is a worldwide uranium rush. To produce the 25 tonnes or so of uranium fuel needed to keep your average reactor going for a year entails the extraction of half a million tonnes of waste rock and over 100,000 tonnes of mill tailings. These are toxic for hundreds of thousands of years. The conversion plant will generate another 144 tonnes of solid waste and 1343 cubic metres of liquid waste. Contamination of local water supplies around uranium mines and processing plants has been documented in Brazil, Colorado, Texas, Australia, Namibia and many other sites. To supply even a fraction of the power stations the industry expects to be online worldwide in 2020 would mean generating 50 million tonnes of toxic radioactive residues every single year. These tailings contain uranium, thorium, radium, polonium, and emit radon-222. In the US, the Environmental Protection Agency sets limits of emissions from the dumps and monitors them. This does not happen in many less developed areas. The long-term management cost of these dumps is left out of the current market prices for nuclear fuel and may be as high as the uranium cost itself. The situation for the depleted uranium waste arising during enrichment even may be worse, says the World Information Service on Energy. No one can convince me that the above process is carbon-free, as politicians claim. It takes a lot of – almost certainly fossil-fuelled – energy to move that amount of rock and process the ore. But the carbon cost is often not in the country where the fuel is consumed. And what of the other costs? Over half of the world's uranium is in Australia and Canada. In Australia the government is planning to make money from the nuclear renaissance being predicted; uranium mining is expanding everywhere. Australian Greens are fast losing the optimism they felt when the Labor party won the last election. In the Northern Territory plans to expand a nuclear dump at Muckaty station are being pushed forward with no regard for the land's Aboriginal owners. The supposedly greener new Australian government Minister Martin Ferguson has failed to deliver an election promise to overturn the Howard government's Commonwealth Radioactive Waste Management Act, which earmarks a series of sites for nuclear waste dumps. In South Australia, in August the Australian government approved the expansion of a controversial uranium mine, Beverley ISL. This was dubbed a "blank cheque licence for pollution". Groundwater specialist Dr Gavin Mudd has examined the data from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and called for it to be "independently verified by people not subservient to the mining industry" (The Epoch Times September 2 2008). Elsewhere in the Northern Territory, BHP Billiton plans to have the first of five planned stages of expansion at its Olympic Dam mine in production by 2013. This will increase production capacity to 200,000 tonnes of copper, 4500 tonnes of uranium and 120,000 ounces of gold. This is a vast open cast mine, from which the wind can carry away radioactive dust. Not far away locals are fighting a new uranium mine 25 kilometres south of Alice Springs. At the Ranger mines, Energy Resources of Australia – 68.4% owned by Rio Tinto – expects to find 30,000 to 40,000 tonnes of ore in the Ranger 3 Deeps area. In October it agreed to supply uranium oxide to a Chinese utility, signing a safety accord. This is how safe the mine in fact is – and you won't find such records at African mines: almost 15,000 litres of acid uranium solution leaked in a 2002 incident, and since then further leaks ranging from 50 to over 23,000 litres have been reported.

#### Unclean water kills millions a year

Seager 6 [Ashley Seager (managing director of Sun4net Ltd. He was the Guardian's economics correspondent for five years and left in 2010), "Dirty water kills 5,000 children a day," The Guardian, 11/10/2006] AZ

Nearly two million children a year die for want of clean water and proper sanitation while the world's poor often pay more for their water than people in Britain or the US, according to a major new report. The United Nations Development Programme, in its annual Human Development report, argues that 1.1 billion people do not have safe water and 2.6 billion suffer from inadequate sewerage. This is not because of water scarcity but poverty, inequality and government failure. The report urges governments to guarantee that each person has at least 20 litres of clean water a day, regardless of wealth, location, gender or ethnicity. If water was free to the poor, it adds, it could trigger the next leap forward in human development. Many sub-Saharan Africans get less than 20 litres of water a day and two-thirds have no proper toilets. By contrast, the average Briton uses 150 litres a day while Americans are the world's most profligate, using 600 litres a day. Phoenix, Arizona, uses 1,000 litres per person on average - 100 times as much as Mozambique. "Water, the stuff of life and a basic human right, is at the heart of a daily crisis faced by countless millions of the world's most vulnerable people," says the report's lead author, Kevin Watkins. Hilary Benn, international development secretary, said: "In many developing countries, water companies supply the rich with subsidised water but often don't reach poor people at all. With around 5,000 children dying every day because they drink dirty water, we must do more." Many countries spend less than 1% of national income on water. This needs to rise sharply, as does the share of foreign aid spent on water projects, the UNDP says. It shows how spending on clean water and sanitation led to dramatic advances in health and infant mortality in Britain and the United States in the 1800s. In the world's worst slums, people often pay five to 10 times more than wealthy people in the same cities or in London. This is because they often have to buy water from standpipes and pay a middle man by the bucket. "The poorer you are, the more you pay," says Mr Watkins. Poor people also waste much time walking miles to collect small amounts of water. The report estimates that 40bn hours are spent collecting water each year in sub-Saharan Africa - an entire working year for all the people in France. And the water the poor do get is often contaminated, spreading diseases that kill people or leave them unable to work. The UNDP estimates that nearly half of all people in developing countries at any one time are suffering from an illness caused by bad water or sanitation and that 443m school days are missed each year. There is plenty of water globally but it is not evenly distributed and is difficult to transport. Some countries use more than they have due to irrigation, population growth and so on. But many simply do not handle their water properly.

#### The uranium industry results in the resource curse in developing countries – ensures environmental destruction and unsustainable economic growth

Fundi 12 [(Dr. Shaaban Kitindi Fundi has 16 years of professional and academic experience focusing on marine research techniques, environmental research and education. Shaaban worked for 5 years in the environmental research and education field (2 years at Frontier-Tanzania, 1 year at the Center for Urban Environmental Research and Education and 1 year at Tetra Tech, Inc.) as a Research Assistant and a Consultant on issues related to environmental assessment, management, program evaluation and data analysis), "Will Uranium Mining Be a Natural Resource or Curse to Tanzania?" Kibogoji, February 2012] AZ

Tanzania will soon be joining African countries like Namibia, Niger, and Malawi as uranium exporters if proposed uranium mining projects are approved by the government. Short term benefits of uranium mining include job opportunities for thousands of Tanzanians and tax income for the Tanzanian government. These benefits cannot be ignored. However, the long-term health and environmental consequences associated with uranium and all other mining activities also need to be seriously evaluated.

One important environmental consequence of uranium mining is that the process uses enormous amounts of water. A recent estimate by a mining company in Namibia, Canadian Forsys Metal Company, suggested that its mining operation utilizes 1 million liters of water per day. One of the proposed areas for Uranium mining in Tanzania is in Manyoni District in Singida region. Water is already a scarce commodity in this region and it would be very unwise to let one company consume so much water at the expense of current inhabitants.

In addition to using enormous amount of water, uranium mining relies on open-pit operations which leave huge craters once mining activities have ceased. The soils in the remaining craters are usually contaminated with radioactive materials and therefore the soil become useless for many years in the future.Furthermore, radioactive dust particles can travel by wind to larger areas and affect the health of communities surrounding the mining areas. It has been documented that exposure to even relatively low levels of radiation over a long period of time can be extremely harmful to the health of workers and communities living around uranium mines. What plans are currently in place to ensure that the workers and people already living in these areas are protected and will be taken care of if this radioactive contamination should occur?

Current estimates suggest that Tanzania has about 53.9 million pounds of uranium oxide deposits and at the current price of $41 per pound, these deposits are worth an estimated $2.2 billion. Despite the estimated large sum of dollars, Tanzania has no control over uranium pricing variability on the world market. Demand and supply does. Yet very few countries can actually use uranium for energy generation and bomb creation due to its high cost of operation, need for skilled personnel, and international restrictions on development of nuclear programs. If global demand for uranium were to decrease, the estimated value of these deposits would also decrease. Thus, it is unclear how much revenue uranium mining would really bring to Tanzania.

Furthermore, the Tanzania Mining Act of 1998 gives a disproportionate amount of revenue benefits to mining companies. This has meant that the average Tanzanian citizen has seen limited benefit from current mining projects while the vast majority of profits go to mining companies based in other countries. Take gold, for example. Tanzania is the fourth largest producer of gold in sub-Saharan Africa behind Ghana and South Africa. Yet Tanzanians have failed to benefit from the gold mining ventures in the country. What assurances do Tanzanians have that it will be different for the proposed uranium mining ventures? Given the serious environmental and health impact associated with uranium mining, Tanzania needs a Mining Act that will address the health and environmental concern of its citizens and that will ensure local communities also profit from mining activities. Without a comprehensive legislative framework to deal with all the implications of uranium mining, Tanzania opens itself up to abuse by companies who pursue an agenda of short-term profits and pay very little attention to the long-term health and environmental consequences for the host country and its citizens. Tanzania needs to develop a legislative framework and monitoring program to ensure these companies will protect the welfare of their workers and the environment before allowing mining to start. These tasks require a high level of technical competence and strong political will

The decision whether or not to proceed with uranium mining in Tanzania should be discussed thoroughly with all stakeholders including the mining companies, the government and the local people residing in the proposed mining areas and in the transit routes. The locals should be told about the potential benefits and consequence of the proposed mining including the increased risk for developing cancer associated with living or working in uranium mining areas. Who will be responsible for their health once they start to develop cancer related illnesses? The water issues also need to be looked at carefully. How can the community and the uranium mines share the water resources so that there is enough water for everyone? How can the community share in the revenue generated by the uranium mines? And finally, who will be responsible to remediate the contaminated soils in the crater that will remain after mining operation ceases? These issues need to be decided before the Tanzanian government approves uranium mining in the country.

#### The resource curse causes instability, political repression, and civil violence

Gilles Carbonnier et al 11, Natascha Wagner, and Fritz Brugger, [The Graduate Institute of Geneva Center on Conflict, Development and Peacebuilding], "Oil, Gas, and Minerals: The Impact of Resource-Dependence and Governance on Sustainable Development", The Centre on Conflict, Development, and Peacebuilding Working Paper, 2011.

**“**Most of the resource-curse literature follows Sachs and Warner by assessing development ¶ outcome in terms of GDP growth. This focus on growth in output and value added neglects ¶ variations in stocks. The exploitation of oil, gas and minerals translates into immediate ¶ GDP growth without considering the concomitant depletion of the natural capital base, ¶ in particular the reduction of national sub-soil wealth. In addition, mineral resources are ¶ non-renewable. The exploitation of oil, gas and minerals in low-income countries offers a ¶ time-bound opportunity to mobilize domestic finance for development, since the extractive ¶ rent will die off at some point, depending on the abundance of mineral deposits or oil ¶ reserves and the pace of extraction (Stevens, 2011). In the long run, the development ¶ outcome is closely tied to the allocation of the resource rents between consumption and ¶ investment. In fragile states, the rents are all too often misappropriated and invested in ¶ patronage politics and political repression rather than in infrastructure, health services and ¶ education. This extractive windfall often leads political leaders to overspend on consumption ¶ and non-productive assets, as illustrated by lavish presidential palaces and sumptuary ¶ monuments built across gas-rich Turkmenistan. These expenditures contribute to GDP ¶ growth but certainly not to sustainable development. The rent tends to be perceived as a ¶ prize that can be captured through corruption and armed violence (Humphreys et al., 2007).**”**

### 1AC – Waste

#### A switch to thorium would use up all of the existing nuclear waste and prevent new waste from being dumped

**Rhodes, 12** – Chris Rhodes is a writer and researcher. He studied chemistry at Sussex University, earning both a B.Sc and a Doctoral degree (D.Phil.); rising to become the youngest professor of physical chemistry in the U.K. at the age of 34. A prolific author, Chris has published more than 400 research and popular science articles (some in national newspapers: The Independent and The Daily Telegraph) He has recently published his first novel, "University Shambles" was published in April 2009 (Melrose Books), (Chris, February, “Hopes Build for Thorium Nuclear Energy”, http://oilprice.com/Alternative-Energy/Nuclear-Power/Hopes-Build-for-Thorium-Nuclear-Energy.html)//vivienne

There is much written to the effect that thorium might prove a more viable nuclear fuel, and an energy industry based upon it, than the current uranium-based process which serves to provide both energy and weapons - including "depleted uranium" for armaments and missiles. There are different ways in which energy might be extracted from thorium, one of which is the accelerator-driven system (ADS). Such accelerators need massive amounts of electricity to run them, as all particle accelerators do, but these are required to produce a beam of protons of such intensity that until 10 years ago the prevailing technology meant that it could not have been done. As noted below, an alternative means to use thorium as a fuel is in a liquid fluoride reactor (LFR), also termed a molten salt reactor, which avoids the use of solid oxide nuclear fuels. Indeed, China has made the decision to develop an LFR-based thorium-power programme, to be active by 2020.¶ Rather like nuclear fusion, the working ADS technology is some way off, and may never happen, although Professor Egil Lillestol of Bergen University in Norway is pushing that the world should use thorium in such ADS reactors. Using thorium as a nuclear fuel is a laudable idea, as is amply demonstrated in the blog "Energy from Thorium" (http://thoriumenergy.blogspot.com/). However, the European Union has pulled the plug on funding for the thorium ADS programme, which was directed by Professor Carlo Rubbia, the Nobel Prize winner, who has now abandoned his efforts to press forward the programme, and instead concentrated on solar energy, which was another of his activities. Rubbia had appointed Lillestol as leader of the CERN physics division over two decades ago, in 1989, who believes that the cause is not lost.¶ Thorium has many advantages, not the least being its greater abundance than uranium. It is often quoted that there is three times as much thorium as there is uranium. Uranium is around 2 - 3 parts per million in abundance in most soils, and this proportion rises especially where phosphate rocks are present, to anywhere between 50 and 1000 ppm. This is still only in the range 0.005% - 0.1% and so even the best soils are not obvious places to look for uranium. However, somewhere around 6 ppm as an average for thorium in the Earth's crust is a reasonable estimate. There are thorium mineral deposits that contain up to 12% of the element, located at the following tonnages in Turkey (380,000), Australia (300,000), India (290,000), Canada and the US combined (260,000)... and Norway (170,000), perhaps explaining part of Lillestol's enthusiasm for thorium based nuclear power. Indeed, Norway is very well endowed with natural fuel resources, including gas, oil, coal, and it would appear, thorium.¶ An alternative technology to the ADS is the "Liquid Fluoride Reactor" (LFR), which is described and discussed in considerable detail on the http://thoriumenergy.blogspot.com/ blog, and reading this has convinced me that the LFR may provide the best means to achieve our future nuclear energy programme. Thorium exists naturally as thorium-232, which is not of itself a viable nuclear fuel. However, by absorption of relatively low energy "slow" neutrons, it is converted to protactinium 233, which must be removed from the reactor (otherwise it absorbs another neutron and becomes protactinium 234) and allowed to decay over about 28 days to uranium 233, which is fissile, and can be returned to the reactor as a fuel, and to breed more uranium 233 from thorium. The "breeding" cycle can be kicked-off using plutonium say, to provide the initial supply of neutrons, and indeed the LFR would be a useful way of disposing of weapons grade plutonium and uranium from the world's stockpiles while converting it into useful energy.¶ The LFR makes in-situ reprocessing possible, much more easily than is the case for solid-fuel based reactors. I believe there have been two working LFR's to date, and if implemented, the technology would avoid using uranium-plutonium fast breeder reactors, which need high energy "fast" neutrons to convert uranium 238 which is not fissile to plutonium 239 which is. The LFR is inherently safer and does not require liquid sodium as a coolant, while it also avoids the risk of plutonium getting into the hands of terrorists. It is worth noting that while uranium 235 and plutonium 239 could be shielded to avoid detection as a "bomb in a suitcase", uranium 233 could not, because it is always contaminated with uranium 232, which is a strong gamma-ray emitter, and is far less easily concealed.¶ It has been claimed that thorium produces "250 times more energy per unit of weight" than uranium. Now this isn't simply a "logs versus coal on the fire" kind of argument, but presumably refers to the fact that while essentially all the thorium can be used as a fuel, the uranium must be enriched in uranium 235, the rest being "thrown away" and hence wasted as "depleted" uranium 238 (unless it is bred into plutonium). If both the thorium and uranium were used to breed uranium 233 or plutonium 239, then presumably their relative "heat output" weight for weight should be about the same as final fission fuels? If this is wrong, will someone please explain this to me as I should be interested to know?¶ However, allowing that the LFR in-situ reprocessing is a far easier and less dangerous procedure, the simple sums are that contained in 248 million tonnes of natural uranium, available as a reserve, are 1.79 million tonnes of uranium 235 + 246.2 million tonnes of uranium 238. Hence by enrichment 35 million tonnes (Mt) of uranium containing 3.2% uranium 235 (from the original 0.71%) are obtained. This "enriched fraction" would contain 1.12 Mt of (235) + 33.88 Mt of (238), leaving in the other "depleted" fraction 248 - 35 Mt = 213 Mt of the original 248 Mt, and containing 0.67 Mt (235) + 212.3 Mt (238). Thus we have accessed 1.79 - 0.67 = 1.12 Mt of (235) = 1.12/224 = 4.52 x 10\*-3 or 0.452% of the original total uranium. Thus on a relative basis thorium (assuming 100% of it can be used) is 100/0.452 = 221 times as good weight for weight, which is close to the figure claimed, and a small variation in enrichment to a slightly higher level as is sometimes done probably would get us to an advantage factor of 250!¶ Plutonium is a by-product of normal operation of a uranium-fuelled fission reactor. 95 to 97% of the fuel in the reactor is uranium 238. Some of this uranium is converted to plutonium 239 and plutonium 241 - usually about 1000 kg forms after a year of operation. At the end of the cycle (a year to 2 years, typically), very little uranium 235 is left and about 30% of the power produced by the reactor actually comes from plutonium. Hence a degree of "breeding" happens intrinsically and so the practical advantage of uranium raises its head from 1/250 (accepting that figure) to 1/192, which still weighs enormously in favour of thorium!¶ As a rough estimate, 1.4 million tonnes of thorium (about one third the world uranium claimed, which is enough to last another 50 years as a fission fuel) would keep us going for about 200/3 x 50 = 3,333 years. Even if we were to produce all the world's electricity from nuclear that is currently produced using fossil fuels (which would certainly cut our CO2 emissions), we would be O.K. for 3,333/4 = 833 years. More thorium would doubtless be found if it were looked for, and so the basic raw material is not at issue. Being more abundant in most deposits than uranium, its extraction would place less pressure on other fossil fuel resources used for mining and extracting it. Indeed, thorium-electricity could be piped in for that purpose.¶ It all sounds great: however, the infrastructure would be huge to switch over entirely to thorium, as it would to switch to anything else including hydrogen and biofuels. It is this that is the huge mountain of resistance there will be to all kinds of new technology. My belief is that through cuts in energy use following post peak oil (and peak gas), we may be able to produce liquid fuels from coal, possibly using electricity produced from thorium, Thorium produces less of a nuclear waste problem finally, since fewer actinides result from the thorium fuel cycle than that from uranium. Renewables should be implemented wherever possible too, in the final energy mix that will be the fulcrum on which the survival of human civilization is poised.

#### Nuclear colonialism produces the global genocide and destruction of indigenous communities

Ryser et al 16

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Risks of Radioactive and Chemical Exposures Faced by Fourth World Peoples Medical, genetic and social researchers have attempted to understand the complex public health effects of exposure to radioactive elements. Researchers conducting human subjects experiments repeatedly conclude that radioactive exposures cause many serious health problems. Various types of cancers, tumors, genetic mutations, congenital malformations, heart failure, gastrointestinal disorders, immunological dysfunction, and infertility are the common results. For Fourth World peoples, these risks overlap the destruction of culture and heritage, natural resources and and denial of their human rights. Contaminated plants, water, animals, and soil in the world's nuclear "hot spots" are also the foods, medicines, and sacred places. As with any human society these are central to indigenous religions, cultures, identities, societies, economies, and knowledge bases -- life. Thus, the burden of nuclear contamination essentially destroys these life-supporting resources and amounts to cultural genocide, or culturcide. These consequences are particularly acute on the Spokane Indian Reservation, parts of the Confederated Tribes of the Colville Reservation and the Yakama. Health Consequences Radioactive substances carry uniquely dangerous characteristics compared to other toxins made by human industry. When nuclear technology was first being developed, researchers quickly discovered that radioactive isotopes had a "super-poisonous" quality. They destroy cells, damage the immune and digestive system, and accelerate aging and death. Radioactive isotopes accumulate in different organs of the body, including the lungs, thyroid, or kidneys. There, they trigger growth of cancerous cells. Worse, the consequences are far-reaching: they cause trans-generational harm through genetic alteration. Anyone exposed to the fallout of nuclear accidents, waste disposal or tests may experience any number of consequences including increased cancer rates, birth defects, severe cognitive disabilities, premature aging and death. Thyroid cancer and leukemia are among the most common cancers associated with radiation exposure. It is also an established cause of cardiovascular disease and solid tumors. However, It is not just high-levels of radiation exposure that are dangerous. As early as 1956, a report commissioned by the US Atomic Energy Commission (AEC) found that even low-levels of radiation could cause harmful genetic changes in individuals and in entire populations with significant trans-generational results. In a recent major World Health Organization study, scientists pointed to the emissions from nuclear power plants as a specific source of potential increased cancer risk -- particularly from disposed spent radioactive fuel rods. Ecological Consequences Nuclear weapons, electrical power reactors and radioactive materials waste disposal results in the contamination of surface and subsurface water and soil with substances such as radioactive plutonium, uranium, strontium and cesium. These materials increase mutations, and they remain harmfully toxic for thousands or even millions of years. Accidents at nuclear power facilities have resulted in decreases in regional animal and plant populations and damaging food sources, water sources and entire ecosystems. Studies conducted around Hanford, Washington revealed that even small concentrations of nuclear waste damaged plants, contaminated soil, and rendered edible crops dangerous to eat. To date, the only containment "solution" is to bury the waste. However, burial is neither safe nor predictable, since there are no successful ways to dispose of waste or remediate contaminated sites. Various amounts of radioactive materials continue to be found in animals, soils, plants, and water near storage and production facilities. Studies suggest that protracted exposure to nuclear waste has resulted in genetic and epigenetic mutations in wildlife. Cultural Consequences The continuity of cultures in nuclear zones is an unstudied topic. The dynamic relationship between a people, earth and the cosmos is dramatically interrupted when the catastrophic introduction of nuclear radiation and toxic chemicals lays waste on a society. Fourth World nations across the globe repeatedly insist that the states responsible for the contamination of their territories have failed to clean up contaminated sites or to prevent further damage. Even where state's government bodies have tried to manage the health risks of radioactive contamination, they have done so in ways that neglect harmful consequences to cultures. Some state's governments use risk avoidance strategies to reduce or prevent damage to people's health. In northwest United States, for example, the US Department of Ecology uses fish consumptions rates to prevent people from eating irradiated fish -- telling the public not to eat high levels of fish to avoid cancer risks. Instead of cleaning up the waste, or preventing its storage in the first place, avoidance warnings ask Fourth World peoples to stop using foods and medicines, even though they are core aspects of their cultures and community

Peoples in the Nuclear Bull's Eye The Yakama Nation and her neighboring nations (Spokane, Confederated Tribes of the Colville Indian Reservation, Nez Perce, Umatilla and the Confederated Tribes of the Warms Springs Reservation) are in the reach of the Hanford Nuclear Waste Site and the Midnite Uranium Mine. There are six other highly radioactively contaminated sites in Fourth World nation territories worldwide and many more storing spent fuel rods from nuclear power plants as well as radioactive hospital waste. 2016 0328n 3 Figure 2 - Nine states detonated more than 2150 nuclear bombs since 1945 into the present after most bomb tests ceased. (Click to enlarge in new window) An estimated total of twenty additional Fourth World territories in Asia, Europe, Africa, the Middle East, North America and the Pacific Islands similar to the Yakama, Navajo and Shoshone territories in the US function as sites for the detonation of nuclear bombs, and as storage sites for nuclear waste, and toxic chemicals. The United States government and contracted waste management companies have located up to six hundred radiation and toxic chemical waste sites on Indian reservations leasing their land for that purpose. Locating waste disposal sites in these ways easily resulted from legal loopholes Fourth World territories provide -- as spaces where state and international laws regarding environmental health and nuclear waste can be circumvented or laws are non-existent. The nuclear states (United States, Russia, France, Britain, China, Israel, and India) avoid testing weapons or storing radioactive and toxic waste on their own lands. They rather favor territories with relatively low-density populations and limited internal governmental regulation while generally avoiding obtaining informed consent or authorization from the affected communities. Significantly none of the bomb making and waste producing states considered in advance of developing plutonium reactors for bombs and electrical generation how to dispose of the waste safely. Despite all of the technological capabilities making radioactive materials no similar effort was early on developed to control the adverse effects of waste products on life. Burying radioactive waste with the probability of unanticipated emissions and leaks remains the method for disposing of the deadly materials. Some of the toxic sites resulting from more than 2150 nuclear bomb detonations and radioactive dump sites in Fourth World Territories and the responsible governments depicted on the map above include: The French government detonated thirteen nuclear bombs in Tuareg territory (Algeria) in the 1960s. They released radioactive gases into the atmosphere and spread radioactive molten rocks across the land. These events exposed Tuaregs to high levels of radiation. No study to date has been conducted to determine the effects these exposures may have on the health and intergenerational lives of the Tuareg. Kazakh territory on the steppe in northeastern Kazakhstan was the place for hundreds of atmospheric and underground nuclear tests conducted by the Union of Soviet Socialist Republics (Russian Federation is the successor) in the 1940s. Studies conducted years later determined that more than 200,000 Kazakh's and other local residents were exposed to intense radiation. These exposures resulted in high rates of cancers. No follow-up epidemiological studies have been conducted to assess the intergenerational consequences of radioactive exposures. The Uyghurs, Hui and Tadjiks in China's northwestern Xinjiang province were exposed to atomic radiation in 1964 and thermonuclear detonations in 1968. The People's Republic of China established Uyghur territory as its prime nuclear test site. At least two generations of Uyghurs, Hui and Tadjiks (a population of 10.95 million) may continue to experience the effects of radioactive and toxic waste exposures. The Pakistani government conducted nuclear detonations in 1998 in Baluchi territory at Ras Koh Hills. The Baloch Society of North America and Friends of Balochistan organized protests at the Pakistani Embassy during the detonations to call attention to the "heinous crime committed against our people." The Indian government conducted its first nuclear detonation in 1974 and continued nuclear test in 1998 in Rajastan the territory of Bhil. Britain conducted atmospheric tests in the 1950s in the Maralinga home of the Pitjantjatjara and Yankunytjatjara. Studies on these peoples were truncated. They did not result in any conclusions about exposure effects on health and genetic changes. The United States of America conducted more than 1100 nuclear detonations in the atmosphere, underground and aboveground (1944-1998) and nuclear waste dumps solely in Fourth World Territories. Marshal Islanders, Paiutes, Shoshone, Kiribati, Yakama, Spokane, Navajo, Mescalero Apache, and Aleutes are among the peoples directly affected by US radiation releases from 1943 to the present. The Taiwan government through the Taiwan Power Company (Taipower) stores 100,000 barrels of high level nuclear waste from the island country's three nuclear power plants. Storage was located at the Lanyu nuclear waste storage facility built in 1982 on the territory of the Tao (also known by the Japanese name as Yami). The Tao are a fishing people who have occupied their island (Ponso no Tao meaning "island of the people" [Orchid Island]) for at least a thousand years. In 2002 and 2012, there were major protests by the Tao, calling on Taipower to remove the nuclear waste from the island. The Yakama Nation and the Spokane Indian Tribe along the Columbia River host the most radioactively toxic region in the world. The Mescalero Apache are the first Fourth World nation to experience an atomic bomb detonated in their territory. Now many Fourth World nations live in irradiated territories under the nuclear cloud. In the name of "national security" all of the nuclear governments have maintained a policy of deliberately not informing residents of Fourth World territories in advance of nuclear tests. Human subjects experimentation using radioactive materials on native peoples, and siting of nuclear waste dumps go on without consent. No epidemiologic studies been concluded to determine exposure effects on health or cultures. Indeed the US Atomic Energy Commission (AEC) records predating 1974 documenting tests, human subject experimentations and radiation exposures have mysteriously disappeared. All records from 1974 remain top secret and not available for scrutiny outside the AEC or its successor the US Department of Energy.

## Solvency

### Yes Thorium Shift

#### it's feasible – newest ev

INN 7/21 [Investing News Network, "Does Thorium Play a Role in the Future of Nuclear Energy?," 7/21/2016, http://investingnews.com/daily/resource-investing/energy-investing/uranium-investing/thorium-an-alternative-for-nuclear-energy/] AZ

The question of whether thorium works for energy production was answered in 2013, when privately owned Norwegian company Thor Energy began to produce power at its Halden test reactor in Norway using thorium. “It is the fundamental first step in the thorium evolution,” Thor Energy’s CEO, Oystein Asphjell, told Reuters at the time. Nuclear giant Westinghouse, a unit of Toshiba (TSE:6502), is part of an international consortium that Thor Energy established to fund and manage the experiments. An established player in nuclear energy, Westinghouse provides viewpoints on the research. Thor Energy is not the only company engaged in researching whether or not thorium is a viable alternative to uranium in nuclear energy. In fact, firms from the US, Australia and the Czech Republic have also been working on thorium reactor designs and other elements of fuel technology using the metal. However, Thor was the first to begin energy production using the radioactive metal. But the Norwegian company is not the only one making strides in the thorium space. In fact, India has been interested in thorium-based nuclear energy for decades, according to the US Geological Survey (USGS). The country’s nuclear developers have designed an advanced heavy water reactor that is specifically aimed at using thorium as a fuel. Also looking at the prospect of thorium as a fuel source is China, who signed a phase two agreement in 2009 to study the commercial and technical feasibility of its full-scale use in the Candu power system, a heavy water reactor that uses thorium-based fuels. China’s thorium production goal has been set for 2020. In Indonesia, the country’s industry minister, Saleh Husin, has suggested that Indonesia pursues development of thorium-fueled nuclear power plant to take advantage of radioactive material in the country and ensure energy supply for industrial developments. In a statement from May 2016, Husin said, “Thorium is abundant in Bangka Belitung.” He added it is estimated that a thorium-based power plant would only cost three cents per kilowatt hour of energy.

### A2 Not Cost Effective

#### cost effective – this ev is licious

Hargraves and Moir 10 [Robert Hargraves (teaches energy policy at the Institute for Lifelong Education at Dartmouth College, received his Ph.D. in physics from Brown University) and Ralph Moir (Ralph Moir has published 10 papers on molten-salt reactors during his career at Lawrence Livermore National Laboratory. He received his Sc.D. in nuclear engineering from the Massachusetts Institute of Technology), "Liquid Fluoride Thorium Reactors," The Scientific Research Society, July-August 2010] AZ

In terms of cost, the ideal would be to compete successfully against coal without subsidies or market-modifying legislation. It may well be possible. Capital costs are generally higher for conventional nuclear versus fossil-fuel plants, whereas fuel costs are lower. Capital costs are outsized for nuclear plants because the construction, including the containment building, must meet very high standards; the facilities include elaborate, redundant safety systems; and included in capital costs are levies for the cost of decommissioning and removing the plants when they are ultimately taken out of service. The much-consulted MIT study The Future of Nuclear Power, originally published in 2003 and updated in 2009, shows the capital costs of coal plants at $2.30 per watt versus $4 for light-water nuclear. A principal reason why the capital costs of LFTR plants could depart from this ratio is that the LFTR operates at atmospheric pressure and contains no pressurized water. With no water to flash to steam in the event of a pressure breach, a LFTR can use a much more close-fitting containment structure. Other expensive high-pressure coolant-injection systems can also be deleted. One concept for the smaller LFTR containment structure is a hardened concrete facility below ground level, with a robust concrete cap at ground level to resist aircraft impact and any other foreseeable assaults. Other factors contribute to a favorable cost structure, such as simpler fuel handling, smaller components, markedly lower fuel costs and significantly higher energy efficiency. LFTRs are high-temperature reactors, operating at around 800 degrees Celsius, which is thermodynamically favorable for conversion of thermal to electrical energy—a conversion efficiency of 45 percent is likely, versus 33 percent typical of coal and older nuclear plants. The high heat also opens the door for other remunerative uses for the thermal energy, such as hydrogen production, which is greatly facilitated by high temperature, as well as driving other industrial chemical processes with excess process heat. Depending on the siting of a LFTR plant, it could even supply heat for homes and offices. Thorium must also compete economically with energy-efficiency initiatives and renewables. A mature decision process requires that we consider whether renewables and efficiency can realistically answer the rapidly growing energy needs of China, India and the other tiers of the developing world as cheap fossil fuels beckon—at terrible environmental cost. Part of the cost calculation for transitioning to thorium must include its role in the expansion of prosperity in the world, which will be linked inexorably to greater energy demands. We have a pecuniary interest in avoiding the enviromental blowback of a massive upsurge in fossil-fuel consumption in the developing world. The value of providing an alternative to that scenario is hard to monetize, but the consequences of not doing so are impossible to hide from. Perhaps the most compelling idea on the drawing board for pushing thorium-based power into the mainstream is mass production to drive rapid deployment in the U.S. and export elsewhere. Business economists observe that commercialization of any technology leads to lower costs as the number of units increases and the experience curve delivers benefits in work specialization, refined production processes, product standardization and efficient product redesign. Given the diminished scale of LFTRs, it seems reasonable to project that reactors of 100 megawatts can be factory produced for a cost of around $200 million. Boeing, producing one $200 million airplane per day, could be a model for LFTR production. Modular construction is an important trend in current manufacturing of traditional nuclear plants. The market-leading Westinghouse AP1000 advanced pressurized-water reactor can be built in 36 months from the first pouring of concrete, in part because of its modular construction. The largest module of the AP1000 is a 700-metricton unit that arrives at the construction site with rooms completely wired, pipefitted and painted. Quality benefits from modular construction because inspection can consist of a set of protocols executed by specialists operating in a dedicated environment. One potential role for mass-produced LFTR plants could be replacing the power generation components of existing fossil-fuel fired plants, while integrating with the existing electrical-distribution infrastructure already wired to those sites. The savings from adapting existing infrastructure could be very large indeed.

## Prolif

### A2 Thorium = Prolif

#### Thorium doesn’t cause proliferation

**McKenna, 12** – Reporter for Popular Mechanics, focused on alternative energy (Phil, “Is the "Superfuel" Thorium Riskier Than We Thought?” Popular Mechanics, December 5, http://www.popularmechanics.com/science/energy/nuclear/is-the-superfuel-thorium-riskier-than-we-thought-14821644)//vivienne

But Ashley and his co-authors say a simple tweak in the thorium irradiation recipe can sidestep the radioactive isotope’s formation. If an element known as protactinium-233 is extracted from thorium early in the irradiation process, no uranium-232 will form. Instead, the separated protactinium-233 will decay into high purity uranium-233, which can be used in nuclear weapons. "Eight kilograms of uranium-233 can be used for a nuclear weapon," Ashley says. "The International Atomic Energy Agency views it the same as plutonium in terms of proliferation risk." Creating weapons-grade uranium in this way would require someone to have access to a nuclear reactor during the irradiation of thorium fuel, so it’s not likely a terrorist group would be able to carry out the conversion. The bigger threat is that a country pursuing nuclear energy and nuclear weapons (say, Iran) could make both from thorium. "This technology could have a dual civilian and military use," Ashley says. Laurence O’Hagan is the CEO of the Weinberg Foundation, a non-profit organization promoting the development of thorium fuel. Responding to Ashley’s Nature article, O’Hagan says proliferation concerns are overstated. "There are proliferation issues with anything nuclear," he says. "But if you are out to make a bomb, you go after plutonium rather than thorium and uranium-233. It’s too difficult to handle." Thierry Dujardin, deputy director for science and development of the Organisation for Economic Co-operation and Development’s Nuclear Energy Agency takes a middle of the road approach to concerns over proliferation with thorium. "It’s probably as wrong to claim there is no proliferation concern as to say it’s worse than other fuels," Dujardin says. Interest in thorium has been growing in recent years. After the recent nuclear disaster in Fukushima, Japan, some see it as a safer alternative to nuclear reactors powered by uranium. O’Hagan advocates for the use of liquid thorium fuel in high-temperature molten salt reactors. The combination, he says, would allow for small modular reactors that are safer than existing technology and yield far less nuclear waste.

#### no prolif – uranium-232 can't be separated out and checks solve

Schaffer 13 [Marvin B. Schaffer (researcher in accelerator Physics, Medical Physics, Nuclear Physics at RAND Corporation), "Abundant thorium as an alternative nuclear fuel Important waste disposal and weapon proliferation advantages," Energy Policy Journal, 2013] AZ

Uranium-233 as transmuted in the thorium fuel cycle is typically contaminated with uranium-232 and is not easily separated from it. Uranium-232 has several decay products that emit high-energy gamma radiation, a radiological hazard that necessitates the use of remote handling equipment. As long as that material is in a reactor, it is not a problem and is eventually burned while producing energy. However, if the uranium-233 is removed and used for producing a military bomb, the trace uranium-232 can damage the accompanying electronics. Although it has been used in some early nuclear bomb tests, uranium-233 is therefore largely proliferation-resistant, more so than uranium- 235 and plutonium-239. Proliferation resistance of thorium has recently been discussed by S.F. Ashley et. al. (Proliferation Resistance of Thorium-UraniumFuel2.) To reiterate, thorium-232 can be used to breed uranium-233 useful for producing commercial energy and possibly for making nuclear weapons. However, if a molten salt reactor configuration is used, only a small amount of uranium-233 is made. It is difficult to extract, and is contaminated with highly radioactive uranium-232. The proliferation potential is therefore low. Moreover, by adding uranium-238 to the thorium, the troublesome uranium-233 can be denatured and made non-critical through dilution.

## DA

### A2 Warming DA

#### Thorium solves need for fossil fuels

Evans-Pritchard 10 [Ambrose Evans-Pritchard (International Business Editor), "Obama could kill fossil fuels overnight with a nuclear dash for thorium," The Telegraph, 8/29/2010] AZ

We could then stop arguing about wind mills, deepwater drilling, IPCC hockey sticks, or strategic reliance on the Kremlin. History will move on fast. Muddling on with the status quo is not a grown-up policy. The International Energy Agency says the world must invest $26 trillion (£16.7 trillion) over the next 20 years to avert an energy shock. The scramble for scarce fuel is already leading to friction between China, India, and the West. There is no certain bet in nuclear physics but work by Nobel laureate Carlo Rubbia at CERN (European Organization for Nuclear Research) on the use of thorium as a cheap, clean and safe alternative to uranium in reactors may be the magic bullet we have all been hoping for, though we have barely begun to crack the potential of solar power. Dr Rubbia says a tonne of the silvery metal – named after the Norse god of thunder, who also gave us Thor’s day or Thursday - produces as much energy as 200 tonnes of uranium, or 3,500,000 tonnes of coal. A mere fistful would light London for a week. Thorium burns the plutonium residue left by uranium reactors, acting as an eco-cleaner. "It’s the Big One," said Kirk Sorensen, a former NASA rocket engineer and now chief nuclear technologist at Teledyne Brown Engineering. "Once you start looking more closely, it blows your mind away. You can run civilisation on thorium for hundreds of thousands of years, and it’s essentially free. You don’t have to deal with uranium cartels," he said. Thorium is so common that miners treat it as a nuisance, a radioactive by-product if they try to dig up rare earth metals. The US and Australia are full of the stuff. So are the granite rocks of Cornwall. You do not need much: all is potentially usable as fuel, compared to just 0.7pc for uranium.

## T/Theory

### A2 Solvency Advocates Theory

#### We meet – our author explicitly opposes uranium based reactors

#### Counterinterp – the aff needs an author opposed to the continuation of the type of nuclear power the plan prohibits

#### solves their offense – don't need a card that literally says "ban uranium reactors"

#### their interp would make being aff impossible – standards for what constitutes a solvency advocate are far too strict

### A2 T – Nuclear Power

#### Merriam-Webster defines nuclear power as

energy that is created by splitting apart the nuclei of atoms

#### We don't underlimit – the aff can only ban reactors that use fission reactions, not fusion or experimental reactors

### A2 T – Prohibit

#### Prohibit merely means to hinder

Collins English Dictionary – Complete and Unabridged, 12th Edition 2014 © HarperCollins Publishers 1991, 1994, 1998, 2000, 2003, 2006, 2007, 2009, 2011, 2014 http://www.thefreedictionary.com/prohibit

to hinder or prevent

#### Aff flex – the topic is heavily neg biased already – forcing the aff to defend the categorical ban of all nuclear power makes being aff impossible and grants them a huge variety based on regulation, process, and PICs – allowing the aff to specify a type of nuclear power levels the playing field

#### Neg generics still apply – all their links are in the context of uranium reactors, since those are the ones used currently

#### We don't underlimit – there are only five types of nuclear reactors: light water, heavy water, fast breeder, graphite, and thorium.

#### [A2 GROUND] They have plenty of ground – say that countries won't shift to thorium, that thorium fails, the shift won't be fast enough

#### [A2 "HAVE TO REDUCE PRODUCTION"] Their interp is contrived and mixes burdens – the aff shouldn't have to prove that they reduce power production in order to be topical, since that would make topicality a question of solvency –any doubt about whether the aff solves is potentially an auto-loss on T

## WIP

### plan text

#### Countries ought to prohibit the production of nuclear power by uranium-fueled reactors.

### cutting board

#### Uranium is preferred over thorium ONLY because of states' desire for prolif

Hadhazy 14 [Adam Hadhazy (freelance science writer based in New Jersey, assistant science writer for the European Southern Observatory, a contributing writer for Natural History and the Editor-in-Chief of the astronomy news aggregator website Portal to the Universe), "Why Aren't We Using Thorium in Nuclear Reactors?," Discover Magazine, 5/7/2014, http://discovermagazine.com/2014/june/3-ask-discover] AZ

Why aren’t we using thorium in nuclear reactors, given the possibility of a meltdown is nearly zero and the waste cannot be used to make bombs? — Dennis Dorando, Concord, Calif. In a word: precedent. It’s certainly possible to base nuclear reactors around thorium, as opposed to the most commonly used element, uranium. And thorium reactors likely would be somewhat safer because of thorium-based fuel’s greater stability versus uranium-based fuel, with the added benefit of not producing as much nuclear bomb fuel. Of course, they’re still not perfect. Even though a conventional meltdown would be unlikely, thorium still produces harmful radiation that needs to be contained, and something could always go wrong. But the real reason we use uranium over thorium is a result of wartime politics. Cold War-era governments (including ours) backed uranium-based reactors because they produced plutonium — handy for making nuclear weapons. With some modifications, today’s commercial nuclear reactors could switch to thorium-based fuels, but at great cost. Thorium nuclear power might well be the answer for some countries, though; India and China are investing heavily in its development.

#### Uq counterplan for renewables and thorium fails

Beranek 14 [Jan Beranek (leader of Greenpeace International’s Energy Campaign), "The mythologies of thorium and uranium," Greenpeace International, 3/24/2014] AZ

No proliferation? Yes, thorium can’t itself be used to build nuclear weapons but it can’t be used directly as a nuclear fuel either. In fact, it has to be first converted into the fissile uranium isotope, U-233. That's an isotope that is suitable for nuclear weapons. The US successfully detonated a nuclear bomb containing U-233 in 1955. Even the UK Department of Energy and Climate Change commissioned a report which concluded in 2012 that the claims by thorium proponents who say that the radioactive chemical element makes it impossible to build a bomb from nuclear waste, leaves less hazardous waste than uranium reactors, and that it runs more efficiently, are "overstated". Thorium reactors exist only in blueprints and early experiments, which means there could be other issues not yet detected that would complicate their large scale implementation. In any case, this also means that it would take much longer than a decade before thorium reactors would potentially become available for a larger commercial deployment. Recent studies, like the one published by the Norwegian thorium commission, while being supportive of the concept, also conclude that there are many uncertainties and problems related to it. It notes that Norwegian thorium reserves are of limited economic attractiveness compared to other sources; that accelerator-based reactors will be viable in the distant future at best; that thorium reactors would create nuclear waste problems; and that any of this will require massive international research. Related to this is thorium's unknown economic performance. Experts suggest that one of the key reasons why thorium reactors are not being developed is that they cannot compete economically with uranium fuel-based reactors, due to more complicated fuel fabrication and processing. And current pressurized water reactors are already uncompetitive. With investment costs of current reactor technology easily reaching 8,000 USD/kW of installed capacity, it is difficult to imagine that thorium reactors would be developed and built in foreseeable future. All in all, it rather looks like the nuclear industry, failing terribly to provide a reliable and affordable energy source, is trying to divert our attention from its scandals and incompetence to a distant, rosy dream. Not bad PR but not much else. While we are once again told to dream about a bright nuclear future, modern renewable energy technologies are already cheaper and upscaled well beyond nuclear: in 2013, while only 4,000 MW was globally installed in four single reactors, installations of wind and solar combined reached 80,000 MW. Those newly added capacities of wind and solar alone will generate, on an annual basis, as much electricity as twenty large reactors.

#### Doesn't cause meltdowns

Warmflash 15 [David Warmflash (astrobiologist and science writer. He received his M.D. from Tel Aviv University Sackler School of Medicine, and has done post doctoral work at Brandeis University, the University of Pennsylvania, and the Johnson Space Center, where he was part of the NASA's first cohort of astrobiology training fellows. He has been involved in science outreach for more than a decade and since 2002 has collaborated with The Planetary Society on studying the effects of the space environment on small organisms), "Thorium Power Is the Safer Future of Nuclear Energy," Discover Magazine, 1/16/2015] AZ

The isotope of thorium that’s being studied for power is called Th-232. Like uranium, Th-232 comes from rocks in the ground. A thorium reactor would work like this: Th-232 is placed in a reactor, where it is bombarded with a beam of neutrons. In accepting a neutron from the beam, Th-232 becomes Th-233, but this heavier isotope doesn’t last very long. The Th-233 decays to protactinium-233, which further decays into U-233. The U-233 remains in the reactor and, similar to current nuclear power plants, the fission of the uranium generates intense heat that can be converted to electricity. To keep the process going, the U-233 must be created continuously by keeping the neutron-generating accelerator turned on. By contrast the neutrons that trigger U-235 fission in a conventional reactor are generated from the fuel itself. The process continues in a chain reaction and can be controlled or stopped only by inserting rods of neutron-absorbing material into the reactor core. But these control rods aren’t foolproof: their operation can be affected during a reactor malfunction. This is the reason that a conventional fission reactor has the potential to start heating out of control and cause an accident. A thorium fuel cycle, by contrast, can be immediately shut down by turning off the supply of neutrons. Shutting down the fuel cycle means preventing the breeding of Th-232 into U-233. This doesn’t stop the heating in the reactor immediately, but it stops it from getting worse. The increased safety of thorium power does not end there. Unlike the U-235 and plutonium fuel cycles, the thorium reactors can be designed to operate in a liquid state. While a conventional reactor heading to meltdown has no way to jettison the fuel to stop the fission reactions, a thorium reactor design called LFTR features a plug at the bottom of the reactor that will melt if the temperature of the reacting fuel climbs too high. If that happens the hot liquid would all drain out and the reaction would stop.

#### it's comparably cheaper – enrichment, extraction, and maintenance

Schaffer 13 [Marvin B. Schaffer (researcher in accelerator Physics, Medical Physics, Nuclear Physics at RAND Corporation), "Abundant thorium as an alternative nuclear fuel Important waste disposal and weapon proliferation advantages," Energy Policy Journal, 2013] AZ

Thorium ore is distributed widely throughout the world. Monazite containing 6–12% thorium phosphate is the primary source. Thorium is extracted from monazite through a complex multi-stage process. Monazite sand is first dissolved in hot concentrated sulfuric acid, and thorium is then extracted in an organic phase containing an amine. Next it is stripped in an aqueous ionic solution and finally thorium oxide is precipitated (Barghusan and Smutz, 1958). Table 2 summarizes world thorium reserves. India, the United States, Australia and Canada have the largest resources. Thorium comes out of the ground as a usable isotope that does not require enrichment. In contrast, natural uranium contains only 0.7% fissionable uranium-235 and generally requires expensive enrichment (to 3–5% or more) when used in commercial light water reactors. Separation of the uranium isotopes is done principally by gaseous centrifugation of UF6 and requires many stages forming a cascade (Fig. 7). New centrifuge plant construction in the United States is very costly, approximately $1–3 billion (World Nuclear Association). Estimated driving costs for a number of reactor alternatives are summarized in Table 3. Light water reactors are impacted by high uranium costs that are initially three times the cost of thorium and further impacted by the cost of enrichment. Illustratively, a 2007 cost estimate for 5% enriched uranium in a 1300 MW reactor was about 75 million dollars annually (Simnad). Given the expectation that enriched uranium costs will continue to increase over the long term, we estimate an average $100 million per year. Over a 50-year lifetime, uranium costs would then total 5 billion dollars. Another big-ticket item for light water reactors is the reactor vessel itself, the cost of which is small relative to enriched uranium fuel but nevertheless amounting to about one billion dollars. On the other hand, CANDU-6 reactors achieve big savings in fuel but depend on heavy water whose estimated initial cost is about 0.3 billion dollars per reactor. Although heavy water is not consumed, there is inevitable leakage. Over a 50-year lifetime, heavy water costs might total about 0.4 billion dollars (Jackson).

#### advantages of liquid fuel

Hargraves and Moir 10 [Robert Hargraves (teaches energy policy at the Institute for Lifelong Education at Dartmouth College, received his Ph.D. in physics from Brown University) and Ralph Moir (Ralph Moir has published 10 papers on molten-salt reactors during his career at Lawrence Livermore National Laboratory. He received his Sc.D. in nuclear engineering from the Massachusetts Institute of Technology), "Liquid Fluoride Thorium Reactors," The Scientific Research Society, July-August 2010] AZ

Liquid fuel thorium reactors offer an array of advantages in design, operation, safety, waste management, cost and proliferation resistance over the traditional configuration of nuclear plants. Individually, the advantages are intriguing. Collectively they are compelling. Unlike solid nuclear fuel, liquid fluoride salts are impervious to radiation damage. We mentioned earlier that fuel rods acquire structural damage from the heat and radiation of the nuclear furnace. Replacing them requires expensive shutdown of the plant about every 18 months to swap out a third of the fuel rods while shuffling the remainder. Fresh fuel is not very hazardous, but spent fuel is intensely radioactive and must be handled by remotely operated equipment. After several years of storage underwater to allow highly radioactive fission products to decay to stability, fuel rods can be safely transferred to dry-cask storage. Liquid fluoride fuel is not subject to the structural stresses of solid fuel and its ionic bonds can tolerate unlimited levels of radiation damage, while eliminating the (rather high) cost of fabricating fuel elements and the (also high) cost of periodic shutdowns to replace them. More important are the ways in which liquid fuel accommodates chemical engineering. Within uranium oxide fuel rods, numerous transuranic products are generated, such as plutonium-239, created by the absorption of a neutron by uranium-238, followed by beta decay. Some of this plutonium is fissioned, contributing as much as one-third of the energy production of uranium reactors. All such transuranic elements could eventually be destroyed in the neutron flux, either by direct fission or transmutation to a fissile element, except that the solid fuel must be removed long before complete burnup is achieved. In liquid fuel, transuranic fission products can remain in the fluid fuel of the core, transmuting by neutron absorption until eventually they nearly all undergo fission. In solid fuel rods, fission products are trapped in the structural lattice of the fuel material. In liquid fuel, reaction products can be relatively easily removed. For example, the gaseous fission poison xenon is easy to remove because it bubbles out of solution as the fuel salt is pumped. Separation of materials by this mechanism is central to the main feature of thorium power, which is formation of fissile uranium-233 in the blanket for export to the core. In the fluoride salt of the thorium blanket, newly formed uranium-233 forms soluble uranium tetrafluoride (UF4). Bubbling fluorine gas through the blanket solution converts the uranium tetrafluoride into gaseous uranium hexafluoride (UF6), while not chemically affecting the lessreactive thorium tetrafluoride. Uranium hexafluoride comes out of solution, is captured, then is reduced back to soluble UF4 by hydrogen gas in a reduction column, and finally is directed to the core to serve as fissile fuel. Other fission products such as molybdenum, neodymium and technetium can be easily removed from liquid fuel by fluorination or plating techniques, greatly prolonging the viability and efficiency of the liquid fuel. Liquid fluoride solutions are familiar chemistry. Millions of metric tons of liquid fluoride salts circulate through hundreds of aluminum chemical plants daily, and all uranium used in today’s reactors has to pass in and out of a fluoride form in order to be enriched. The LFTR technology is in many ways a straightforward extension of contemporary nuclear chemical engineering

#### solves waste

Hargraves and Moir 10 [Robert Hargraves (teaches energy policy at the Institute for Lifelong Education at Dartmouth College, received his Ph.D. in physics from Brown University) and Ralph Moir (Ralph Moir has published 10 papers on molten-salt reactors during his career at Lawrence Livermore National Laboratory. He received his Sc.D. in nuclear engineering from the Massachusetts Institute of Technology), "Liquid Fluoride Thorium Reactors," The Scientific Research Society, July-August 2010] AZ

Among the most attractive features of the LFTR design is its waste profile. It makes very little. Recently, the problem of nuclear waste generated during the uranium era has become both more and less urgent. It is more urgent because as of early 2009, the Obama administration has ruled that the Yucca Mountain Repository, the site designated for the permanent geological isolation of existing U.S. nuclear waste, is no longer to be considered an option. Without Yucca Mountain as a strategy for waste disposal, the U.S. has no strategy at all. In May 2009, Secretary of Energy Steven Chu, Nobel laureate in physics, said that Yucca Mountain is off the table. What we’re going to be doing is saying, let’s step back. We realize that we know a lot more today than we did 25 or 30 years ago. The [Nuclear Regulatory Commission] is saying that the dry-cask storage at current sites would be safe for many decades, so that gives us time to figure out what we should do for a long-term strategy. The waste problem has become somewhat less urgent because many stakeholders believe Secretary Chu is correct that the waste, secured in huge, hardened casks under adequate guard, is in fact not vulnerable to any foreseeable accident or mischief in the near future, buying time to develop a sound plan for its permanent disposal. A sound plan we must have. One component of a long-range plan that would keep the growing problem from getting worse while meeting growing power needs would be to mobilize nuclear technology that creates far less waste that is far less toxic. The liquid fluoride thorium reactor answers that need. Thorium and uranium reactors produce essentially the same fission (breakdown) products, but they produce a quite different spectrum of actinides (the elements above actinium in the periodic table, produced in reactors by neutron absorption and transmutation). The various isotopes of these elements are the main contributors to the very long-term radiotoxicity of nuclear waste. The mass number of thorium-232 is six units less than that of uranium- 238, thus many more neutron captures are required to transmute thorium to the first transuranic. Figure 6 shows that the radiotoxicity of wastes from a thorium/uranium fuel cycle is far lower than that of the currently employed uranium/plutonium cycle— after 300 years, it is about 10,000 times less toxic. By statute, the U.S. government has sole responsibility for the nuclear waste that has so far been produced and has collected $25 billion in fees from nuclear-power producers over the past 30 years to deal with it. Inaction on the waste front, to borrow the words of the Obama administration, is not an option. Many feel that some of the $25 billion collected so far would be well spent kickstarting research on thorium power to contribute to future power with minimal waste.

#### very good safety features

Hargraves and Moir 10 [Robert Hargraves (teaches energy policy at the Institute for Lifelong Education at Dartmouth College, received his Ph.D. in physics from Brown University) and Ralph Moir (Ralph Moir has published 10 papers on molten-salt reactors during his career at Lawrence Livermore National Laboratory. He received his Sc.D. in nuclear engineering from the Massachusetts Institute of Technology), "Liquid Fluoride Thorium Reactors," The Scientific Research Society, July-August 2010] AZ

It has always been the dream of reactor designers to produce plants with inherent safety—reactor assembly, fuel and power-generation components engineered in such a way that the reactor will, without human intervention, remain stable or shut itself down in response to any accident, electrical outage, abnormal change in load or other mishap. The LFTR design appears, in its present state of research and design, to possess an extremely high degree of inherent safety. The single most volatile aspect of current nuclear reactors is the pressurized water. In boiling light-water, pressurized light-water, and heavywater reactors (accounting for nearly all of the 441 reactors worldwide), water serves as the coolant and neutron moderator. The heat of fission causes water to boil, either directly in the core or in a steam generator, producing steam that drives a turbine. The water is maintained at high pressure to raise its boiling temperature. The explosive pressures involved are contained by a system of highly engineered, highly expensive piping and pressure vessels (called the “pressure boundary”), and the ultimate line of defense is the massive, expensive containment building surrounding the reactor, designed to withstand any explosive calamity and prevent the release of radioactive materials propelled by pressurized steam. A signature safety feature of the LFTR design is that the coolant—liquid fluoride salt—is not under pressure. The fluoride salt does not boil below 1400 degrees Celsius. Neutral pressure reduces the cost and the scale of LFTR plant construction by reducing the scale of the containment requirements, because it obviates the need to contain a pressure explosion. Disruption in a transport line would result in a leak, not an explosion, which would be captured in a noncritical configuration in a catch basin, where it would passively cool and harden. Another safety feature of LFTRs, shared with all of the new generation of LWRs, is its negative temperature coefficient of reactivity. Meltdown, the bogey of the early nuclear era, has been effectively designed out of modern nuclear fuels by engineering them so that power excursions—the industry term for runaway reactors—are self-limiting. For example, if the temperature in a reactor rises beyond the intended regime, signaling a power excursion, the fuel itself responds with thermal expansion, reducing the effective area for neutron absorption—the temperature coefficient of reactivity is negative—thus suppressing the rate of fission and causing the temperature to fall. With appropriate formulations and configurations of nuclear fuel, of which there are now a number from which to choose among solid fuels, runaway reactivity becomes implausible. In the LFTR, thermal expansion of the liquid fuel and the moderator vessel containing it reduces the reactivity of the core. This response permits the desirable property of load following— under conditions of changing electricity demand (load), the reactor requires no intervention to respond with automatic increases or decreases in power production. As a second tier of defense, LFTR designs have a freeze plug at the bottom of the core—a plug of salt, cooled by a fan to keep it at a temperature below the freezing point of the salt. If temperature rises beyond a critical point, the plug melts, and the liquid fuel in the core is immediately evacuated, pouring into a subcritical geometry in a catch basin. This formidable safety tactic is only possible if the fuel is a liquid. One of the current requirements of the Nuclear Regulatory Commission (NRC) for certification of a new nuclear plant design is that in the event of a complete electricity outage, the reactor remain at least stable for several days if it is not automatically deactivated. As it happens, the freezeplug safety feature is as old as Alvin Weinberg’s 1965 Molten Salt Reactor Experiment design, yet it meets the NRC’s requirement; at ORNL, the “old nukes” would routinely shut down the reactor by simply cutting the power to the freeze-plug cooling system. This setup is the ultimate in safe poweroutage response. Power isn’t needed to shut down the reactor, for example by manipulating control elements. Instead power is needed to prevent the shutdown of the reactor.

#### non-prolif adv

Hargraves and Moir 10 [Robert Hargraves (teaches energy policy at the Institute for Lifelong Education at Dartmouth College, received his Ph.D. in physics from Brown University) and Ralph Moir (Ralph Moir has published 10 papers on molten-salt reactors during his career at Lawrence Livermore National Laboratory. He received his Sc.D. in nuclear engineering from the Massachusetts Institute of Technology), "Liquid Fluoride Thorium Reactors," The Scientific Research Society, July-August 2010] AZ

Cost competitiveness is a weighty consideration for nuclear power development, but it exists on a somewhat different level from the life-and-death considerations of waste management, safety and nonproliferation. Escalating the role of nuclear power in the world must be anchored to decisively eliminating the illicit diversion of nuclear materials. When the idea of thorium power was first revived in recent years, the focus of discussion was its inherent proliferation resistance (see the September–October 2003 issue of American Scientist; Mujid S. Kazimi, “Thorium Fuel for Nuclear Energy”). The uranium-233 produced from thorium-232 is necessarily accompanied by uranium-232, a proliferation prophylactic. Uranium-232 has a relatively short half-life of 73.6 years, burning itself out by producing decay products that include strong emitters of highenergy gamma radiation. The gamma emissions are easily detectable and highly destructive to ordnance components, circuitry and especially personnel. Uranium-232 is chemically identical to and essentially inseparable from uranium-233. The neutron economy of LFTR designs also contributes to securing its inventory of nuclear materials. In the LFTR core, neutron absorption by uranium-233 produces slightly more than two neutrons per fission—one to drive a subsequent fission and another to drive the conversion of thorium- 232 to uranium-233 in the blanket solution. Over a wide range of energies, uranium-233 emits an average of 2.4 neutrons for each one absorbed. However, taking into account the overall fission rate per capture, capture by other nuclei and so on, a welldesigned LFTR reactor should be able to direct about 1.08 neutrons per fission to thorium transmutation. This delicate poise doesn’t create excess, just enough to generate fuel indefinitely. If meaningful quantities of uranium-233 are misdirected for nonpeaceful purposes, the reactor will report the diversion by winding down because of insufficient fissile product produced in the blanket. Only a determined, well-funded effort on the scale of a national program could overcome the obstacles to illicit use of uranium-232/233 produced in a LFTR reactor. Such an effort would certainly find that it was less problematic to pursue the enrichment of natural uranium or the generation of plutonium. In a world where widespread adoption of LFTR technology undermines the entire, hugely expensive enterprise of uranium enrichment—the necessary first step on the way to plutonium production—bad actors could find their choices narrowing down to unusable uranium and unobtainable plutonium

#### reduces waste dangers

Hall 10 [Vincent Hall, "A review of the benefits and applications of the

thorium fuel cycle," Chemical Engineering Undergraduate Honors

Theses @ UArk, 2010] AZ

The direct disposal of spent thorium fuels would be anticipated to be very similar to that of uranium. Currently, different countries have adopted different methodologies for disposing of nuclear waste. In the U.S, civilian waste remains on-site in large cooling ponds. These large concrete structures serve to provide radiation protection and remove heat generated from radioactive decay. It is intended that after sufficient cooling time, the waste from these pools will be encapsulated and transported to a permanent geological repository such as Yucca Mountain in Nevada or the Waste Isolation Pilot Plant in New Mexico (WNA “Waste Management”). In Canada, long term waste management plans involve placement of the waste in corrosion resistant containers enclosed by a clay-based buffer barrier. These containers are then set into a deeply excavated granite vault for permanent disposal (IAEA 76). In Europe, much of the spent fuel is actually reprocessed in either the UK or France. The recovered fuel is returned to the plants, while the waste is vitrified, sealed in stainless containers, and either stored at the reprocessing facility or returned as well. Eventually, the waste will also be sent to permanent geological disposal (WNA “Nuclear Waste Management”). Thus, regardless of when and how the waste gets there, a geological repository is the final step in waste management for all countries. It is here were thorium based fuels hold the advantage over traditional uranium fuels. The high chemical stability of ThO2 and its very low solubility in groundwater aids in its retention of harmful fission products, making it suitable for direct geological disposal. Also, it has bee shown that fission gas release 24 from defected thorium fuel elements is 1 to 2 orders of magnitude lower than that of uranium and that release of Br, Cs, and Rb from the fuel matrix is much slower as well (IAEA 78). In the event of a rupture of the casing material during permanent disposal, a gas leak containing radioactive material would pose safety and logistics issues, which a thorium fuel cycle would moderate.

## neg answers

### no solvency

#### Thorium doesn’t solve – multiple reasons

**Rees, 11** – Reporter for the Ecologist (Eifion, “Don't believe the spin on thorium being a ‘greener’ nuclear option,” Ecologist, June 23, http://www.theecologist.org/News/news\_analysis/952238/dont\_believe\_the\_spin\_on\_thorium\_being\_a\_greener\_nuclear\_option.html)//vivienne

And yet the nuclear industry itself is also sceptical, with none of the big players backing what should be – in PR terms and in a post-Fukushima world – its radioactive holy grail: safe reactors producing more energy for less and cheaper fuel.   In fact, a 2010 National Nuclear Laboratory (NNL) report concluded the thorium fuel cycle ‘does not currently have a role to play in the UK context [and] is likely to have only a limited role internationally for some years ahead’ – in short, it concluded, the claims for thorium were ‘overstated’. Proponents counter that the NNL paper fails to address the question of MSR technology, evidence of its bias towards an industry wedded to PWRs. Reliant on diverse uranium/plutonium revenue streams – fuel packages and fuel reprocessing, for example – the nuclear energy giants will never give thorium a fair hearing, they say. But even were its commercial viability established, given 2010’s soaring greenhouse gas levels, thorium is one magic bullet that is years off target. Those who support renewables say they will have come so far in cost and efficiency terms by the time the technology is perfected and upscaled that thorium reactors will already be uneconomic. Indeed, if renewables had a fraction of nuclear’s current subsidies they could already be light years ahead.    Extra radioactive waste All other issues aside, thorium is still nuclear energy, say environmentalists, its reactors disgorging the same toxic byproducts and fissile waste with the same millennial half-lives. Oliver Tickell, author of Kyoto2, says the fission materials produced from thorium are of a different spectrum to those from uranium-235, but ‘include many dangerous-to-health alpha and beta emitters’. Tickell says thorium reactors would not reduce the volume of waste from uranium reactors. ‘It will create a whole new volume of radioactive waste, on top of the waste from uranium reactors. Looked at in these terms, it’s a way of multiplying the volume of radioactive waste humanity can create several times over.’ Putative waste benefits – such as the impressive claims made by former Nasa scientist Kirk Sorensen, one of thorium’s staunchest advocates – have the potential to be outweighed by a proliferating number of MSRs. There are already 442 traditional reactors already in operation globally, according to the International Atomic Energy Agency. The by-products of thousands of smaller, ostensibly less wasteful reactors would soon add up. Anti-nuclear campaigner Peter Karamoskos goes further, dismissing a ‘dishonest fantasy’ perpetuated by the pro-nuclear lobby. Thorium cannot in itself power a reactor; unlike natural uranium, it does not contain enough fissile material to initiate a nuclear chain reaction. As a result it must first be bombarded with neutrons to produce the highly radioactive isotope uranium-233 – ‘so these are really U-233 reactors,’ says Karamoskos. This isotope is more hazardous than the U-235 used in conventional reactors, he adds, because it produces U-232 as a side effect (half life: 160,000 years), on top of familiar fission by-products such as technetium-99 (half life: up to 300,000 years) and iodine-129 (half life: 15.7 million years).  Add in actinides such as protactinium-231 (half life: 33,000 years) and it soon becomes apparent that thorium’s superficial cleanliness will still depend on digging some pretty deep holes to bury the highly radioactive waste. Thorium for the UK? With billions of pounds already spent on nuclear research, reactor construction and decommissioning costs – dwarfing commitments to renewables – and proposed reform of the UK electricity markets apparently hiding subsidies to the nuclear industry, the thorium dream is considered by many to be a dangerous diversion. Energy consultant and former Friends of the Earth anti-nuclear campaigner Neil Crumpton says the government would be better deferring all decisions about its new nuclear building plans and fuel reprocessing until the early 2020s: ‘By that time much more will be known about Generation IV technologies including LFTRs and their waste-consuming capability.’ In the meantime, says Jean McSorley, senior consultant for Greenpeace’s nuclear campaign, the pressing issue is to reduce energy demand and implement a major renewables programme in the UK and internationally – after all, even conventional nuclear reactors will not deliver what the world needs in terms of safe, affordable electricity, let alone a whole raft of new ones. ‘Even if thorium technology does progress to the point where it might be commercially viable, it will face the same problems as conventional nuclear: it is not renewable or sustainable and cannot effectively connect to smart grids. The technology is not tried and tested, and none of the main players is interested. Thorium reactors are no more than a distraction.’

#### Thorium is hype – no support

**Rees, 11** – Reporter for the Ecologist (Eifion, “Don't believe the spin on thorium being a ‘greener’ nuclear option,” Ecologist, June 23, http://www.theecologist.org/News/news\_analysis/952238/dont\_believe\_the\_spin\_on\_thorium\_being\_a\_greener\_nuclear\_option.html)//vivienne

The pro-thorium lobby claim a single tonne of thorium burned in a molten salt reactor (MSR) – typically a liquid fluoride thorium reactor (LFTR) – which has liquid rather than solid fuel, can produce one gigawatt of electricity. A traditional pressurised water reactor (PWR) would need to burn 250 tonnes of uranium to produce the same amount of energy. They also produce less waste, have no weapons-grade by-products, can consume legacy plutonium stockpiles and are meltdown-proof – if the hype is to be believed.   Global support for thorium India certainly has faith, with a burgeoning population, chronic electricity shortage, few friends on the global nuclear stage (it hasn’t signed the nuclear non-proliferation treaty) and the world’s largest reserves of thorium. ‘Green’ nuclear could help defuse opposition at home (the approval of two new traditional nuclear power reactors on its west coast led to fierce protests recently) and allow it to push ahead unhindered with its stated aim of generating 270GW of electricity from nuclear by 2050. China, Russia, France and the US are also pursuing the technology, while India’s department of atomic energy and the UK’s Engineering and Physical Sciences Research Council are jointly funding five UK research programmes into it. There is a significant sticking point to the promotion of thorium as the ‘great green hope’ of clean energy production: it remains unproven on a commercial scale. While it has been around since the 1950s (and an experimental 10MW LFTR did run for five years during the 1960s at Oak Ridge National Laboratory in the US, though using uranium and plutonium as fuel) it is still a next generation nuclear technology – theoretical. China did announce this year that it intended to develop a thorium MSR, but nuclear radiologist Peter Karamoskos, of the International Campaign to Abolish Nuclear Weapons (ICAN), says the world shouldn’t hold its breath. ‘Without exception, [thorium reactors] have never been commercially viable, nor do any of the intended new designs even remotely seem to be viable. Like all nuclear power production they rely on extensive taxpayer subsidies; the only difference is that with thorium and other breeder reactors these are of an order of magnitude greater, which is why no government has ever continued their funding.’ China’s development will persist until it experiences the ongoing major technical hurdles the rest of the nuclear club have discovered, he says. Others see thorium as a smokescreen to perpetuate the status quo: the closest the world has come to an operating thorium reactor is India’s Kakrapar-1, a uranium-fuelled PWR that was the first to use thorium to flatten power across the core.   ‘This could be seen to excuse the continued use of PWRs until thorium is [widely] available,’ points out Peter Rowberry of No Money for Nuclear (NM4N) and Communities Against Nuclear Expansion (CANE). In his reading, thorium is merely a way of deflecting attention and criticism from the dangers of the uranium fuel cycle and excusing the pumping of more money into the industry. Why is the nuclear lobby so quiet?   And yet the nuclear industry itself is also sceptical, with none of the big players backing what should be – in PR terms and in a post-Fukushima world – its radioactive holy grail: safe reactors producing more energy for less and cheaper fuel.   In fact, a 2010 National Nuclear Laboratory (NNL) report concluded the thorium fuel cycle ‘does not currently have a role to play in the UK context [and] is likely to have only a limited role internationally for some years ahead’ – in short, it concluded, the claims for thorium were ‘overstated’.

#### Thorium has multiple challenges – radiation and safety

**Williams, 7/13** – a Hong Kong-based writer specialising in conservation and the environment, with a PhD in physical chemistry from Cambridge University (Martin, “Scientists including in China study thorium-fuelled nuclear power,” South China Morning Post, 2014, http://www.scmp.com/lifestyle/technology/article/1552848/scientists-including-china-study-thorium-fuelled-nuclear-power)//vivienne

Reading this, you might think, "Great - let's get started! We can solve the world's energy problems, stabilise the climate, and move on to eliminating poverty and finding a cure for cancer." But there are challenges to overcome, and no one yet knows if these will prove insurmountable. Issues include the process involving isotopes that could be used in nuclear bombs, such as the plutonium or enriched uranium required to convert the thorium and get the reactor started. Also, there will be dangerously radioactive products, requiring safe storage for perhaps tens of thousands of years. There's as yet no agreement regarding the best technology for managing the process, without radioactive and chemically reactive substances plus heat causing damaging to containment vessels. Costs could be prohibitive. Yet with advantages including thorium being about as abundant as lead, plus severe difficulties for making a nuclear bomb from a thorium reactor - partly as it will include the dangerous and easily detectable U-232 uranium isotope, several projects are under way around the world, involving both theoretical and practical work. India is aiming to build thorium-based reactors, favouring designs akin to typical nuclear plants, with solid fuel plus heavy water - which has deuterium rather than hydrogen atoms. A Norwegian project is pioneering use of thorium in a light-water reactor. But the main excitement around thorium centres on the possibility of using salt mixtures with thorium fluoride plus other chemicals, which can become molten during operation. Advantages over reactors utilising water would include higher efficiency as temperatures could be around 800 degrees Celsius, and running at close to atmospheric pressure. Pioneering work on molten-salt reactors was conducted at the US Oak Ridge National Laboratory. Rather than include thorium as envisaged for working reactors, experiments were conducted with uranium isotopes. Though some issues arose, the five-year trial was a success, achieving all objectives. Laboratory director Alvin Weinberg - who had studied the absorption spectrum of carbon dioxide for his master's thesis - warned about the burning of fossil fuels leading to climate change, and believed there could be a solution in nuclear power, particularly using thorium. He was also concerned about safety, which evidently helped lead to him being fired - six years after which came the partial meltdown at Three Mile Island, Pennsylvania. With the US government wanting nuclear reactors that could create plutonium for making bombs, attention shifted away from thorium and molten-salt reactors. These reactors were little known, and thorium became akin to a forgotten fuel, until the recent resurgence of interest. This has been spurred partly by the Weinberg Foundation, which was established in 2011 and is "dedicated to driving awareness, research and the commercialisation of cleaner and safer nuclear technologies, fuelled by thorium". Last month, the foundation reported that a study of the feasibility of a pilot-scale molten-salt reactor had won funding from the British government's strategic innovation agency, the Technology Strategy Board. But never mind shilly-shallying with computer studies and the like, China is leaping into action with an intensive programme to create thorium-powered molten-salt reactors. In March, the South China Morning Post reported that, propelled by the "war on pollution", the Shanghai-based project team had their time frame for achieving this goal shortened from 25 to 10 years. The US Department of Energy - especially its Oak Ridge laboratory - is said to be "quietly collaborating" on the project, and we can only guess at the frustration some of its scientists may feel given previous work was abandoned by a government blinded by desire to build bombs. I've seen the China project described as akin to a nuclear "moon shot". It's indeed ambitious, and may fail. Yet we need something monumental to stave off calamitous climate change, and thorium may yet help us realise Alvin Weinberg's vision of the "Second Nuclear Era". If so - if! - we in Hong Kong may yet experience a stable climate and, whisper it, smog-free skies year-around.

#### **Thorium reactors are dangerous – weaponization and prolif**

Touran, **3/**22 – PhD in Nuclear Engineering, BSE and MSE in nuclear engineering, and working as a reactor physicist on the design of an advanced nuclear reactor for a nuclear innovation company since 2009 (Nick, “Myths about Thorium nuclear fuel,” What is Nuclear? 2014, http://www.whatisnuclear.com/articles/thorium\_myths.html)//vivienne

Dear Internet, we need to have a talk about Thorium. It has many good attributes as a nuclear fuel, but the things being said on the internet have become largely misleading, if not all-out inaccurate. Every internet person I meet in real life who finds out that I am a nuclear engineer asks me why we aren’t using the end-all, be-all that is thorium. Every post regarding nuclear energy on reddit is packed full of comments claiming that Thorium will end all concerns about nuclear energy and that Uranium is only in use due to some dark dark conspiracy. Example: "So why did they go down the Uranium path? Because it was the military running the program, and Thorium reactors aren’t weaponizable." Misleading and half false! Yes, Uranium fuel was certainly developed because it was the easist path to weapons at the time, but these days, the owner of a thorium reactor could certainly make a bomb from it. So they are weaponizable. The internet has become an echo-chamber for this kind of thing and we need to stop it. This page will try to point people in the right direction if they get lost, using things like references and whatnot. And we’ll make a wall of shame where anyone who perpetuates a myth will get to be displayed. To learn about Thorium for real, we feature a page about Thorium as nuclear fuel, as well as a big page about the fluid fueled molten salt reactors (MSRs) that are good at using it. If you think we’re too negative-nancy here, go check out those pages. We love Thorium and think it has a bright future, both in solid and fluid fueled reactors. I personally have studied it a huge amount and many years ago considered getting a THORIUM vanity plate. As we claim elsewhere and throughout comment posts abound, we just think that people need to remain calm and accurate when discussing its merits and demerits. Thorium Myth #1: Development of Thorium-based molten salt reactors got cancelled because they couldn’t make bombs! Quite False. Not only can they be used to make bombs (see Myth #3), but they also were not canceled for any weapons-related reason. One of the most lucid descriptions of what happened to molten salt reactors like the LFTR can be found on page 49 of WASH-1222 [1]. There, they describe a few privately-funded working group studies of the MSBR, including the Molten Salt Breeder Reactor Associates (consisting of the engineering firm Black & Veatch and five midwestern utilities) and the Molten Salt Group, headed by Ebasco Services, Inc. (with 5 other industrial firms and fifteen utilities involved). These groups concluded that the MSBR (basically the LFTR) is attractive and potentially cheaper than LWRs. They said that a demonstration plant is warranted, but the performance cannot be predicted with confidence. Then, a list of factors that limit industrial involvement is given. They include (verbatim): The existing major industrial and utility commitments to the LWR, HTGR, and LMFBR. The lack of incentive for industrial investment in supplying fuel cycle services, such as those required for solid fuel reactors. The overwhelming manufacturing and operating experience with solid fuel reactors in contrast with the very limited involvement with fluid fueled reactors. The less advanced state of MSBR technology and the lack of demonstrated solutions to the major technical problems associated with the MSBR concept. It had nothing to do with weapons. Weapons were produced with graphite or heavy-water moderated production reactors and with gas centrifuge enrichment. Oh, and thermonuclear weapons require tritium as well, which is something that many Thorium MSR designs excel in producing (darn that lithium!). The commercial LWRs had nothing to do with making bomb material. Stop the nonsense. Earlier history will point you to Rickover’s USS Nautilus, which acted as the engineering demonstration of the light water reactor. Since the Navy had already developed the LWR, the commercial industry was much more comfortable going with it and scaling it up. Thorium Myth #2: Thorium reactors never need enrichment! Misleading at best. The nice thing about any breeder reactor (using Th-U or U-Pu) is that eventually they can become fissile self-sufficient, meaning they breed more (or equal) fissile material than they consume. The first electricity-producing reactor in the world (EBR-I in Idaho, 1951) was created to demonstrate that breeding was possible (in a liquid-metal cooled fast breeder reactor, or LMFBR). Any breeder reactor concept on the planet can run without additional enrichment (or some other external source of fissile material) after their initial startup by breeding fissile material out of fertile material like Th-232 or U-238. But you have to start your reactor up with fissile material from somewhere. If you take a vat of Thorium and try to turn it on, you'll be sorely disappointed because it cannot possibly sustain a chain reaction, under any circumstances. So you start it up with denatured bombs or enriched U-235 and then it becomes self-sufficient on Th-232 or U-238. I occasionally read misleading things that say Thorium will just fire right up. Alas. It should be noted, however, that the key advantage of Th fuel is that it allows thermal breeding. This means that you can start up a Th-based breeder with substantially less fissile material than you need to start an equivalent-powered fast breeder reactor. Once started, the fast breeder will make far more fissile material (because they make have a better breeding neutron economy), but the amount of fissile in fast spectrum reactors is always more than in thermal reactors. TL;DR: They do to start up, and U-Pu breeders like the LMFBR can do the same so it’s not Thorium specific. Thorium Myth #3: Thorium reactors cannot make bombs! False! They can indeed make bombs. Thorium reactors work by breeding Th-232 through Protactinium-233 (27.4 day half life) and into Uranium-233, which is fissile. Pa-233 is a pretty strong neutron absorber, so the MSBR (basically the LFTR) has to extract it from the core once it is produced and let it decay to U-233 away from the neutrons. Once the U-233 is created, it gets fed back into the reactor. Well, if you went rogue, you could build up a little excess reactivity (maybe add some low-enriched U235?) and then divert the freshly-bred U-233 into a weapons stream to make U-233 nuclear bombs. It may be difficult to do this several times without going subcritical, but it certainly could be done. A U-233-filled bomb has been tested before, and it worked just fine. Here’s a quote from a Frank von Hippel paper on the subject [2]: "On the one hand, gamma radiation from U-232 makes the U-233 from high- burnup U-233-thorium fuel cycles more of a radiation hazard than plutonium. On the other hand, because of its low rate of spontaneous-neutron emission, U-233 can, unlike plutonium, be used in simple gun-type fission-weapon designs without significant danger of the yield being reduced by premature initiation of the fission chain reaction" And another (also [2]): "In the case of the molten-salt U-233 breeder reactor, it was proposed to have continual chemical processing of a stream of liquid fuel. Such an arrangement also offers a way to completely bypass the U-232 contamination problem because 27-day half-life Pa- 233 could be separated out before it decays into U-233." Options to make bomb-making less favorable include fostering substantial U-232 contamination in the reactor and denaturing the U-233 with U-238 that keeps the in-reactor inventory safe. Both of these options can conceptually be bypassed in the Pa separation route though. Besides, U-232 isn’t releasing the gammas, its decay products are, and it has a 70 year half-life. So you can just chemically purify your stolen goods and then make the bomb anytime within the next decade or so. There are about a dozen other ways people try to amp up the proliferation resistance of various fuel cycles. But they always forget that the owner of such a plant can secretly install a chemical cell that does Pa separation. Really, most civilian power to bombs proliferation paths are mythical, in any reactor! But since the consequences of proliferation are so dire, nuclear power plants need to have baseline proliferation safeguards in place. Thorium-powered reactors, whether fluid fueled or not, are no exception.

#### Thorium fails – it can be turned into a nuclear weapon and has multiple complications

**Edwards, 13** – Ph.D., President at the Canadian Coalition for Nuclear Responsibility (Gordon, “Thorium Reactors and Nuclear Weapons Proliferation: “The Promise and Peril of Thorium”,” Pressenza Hong Kong, 2014, http://www.pressenza.com/2013/08/thorium-reactors-and-nuclear-weapons-proliferation-the-promise-and-peril-of-thorium/)//vivienne

Thorium is a naturally occurring radioactive element, but it is not a nuclear fuel, nor is it a nuclear explosive. The phrase “thorium fuel” is a misnomer. Thorium is not a fuel. However, when thorium is bombarded with neutrons, it is transmuted into a type of uranium that does not exist in nature: uranium-233. This manufactured material, U-233, can subsequently be used as a nuclear fuel or as a nuclear explosive. The article linked below is highly recommended. It provides a good discussion of the weapons proliferation risks associated with thorium-based nuclear reactor technologies. http://wmdjunction.com/121031\_thorium\_reactors.htm To better grasp the proliferation risk, some background on nuclear explosives is helpful. Background on Nuclear Weapons: All existing nuclear weapons use either uranium or plutonium as the primary nuclear explosive material. All nuclear fuels (fuels for nuclear reactors) are also based on either uranium or plutonium. The story begins with naturally occurring uranium…. A. Uranium-235 — Uranium Enrichment Uranium is the only naturally occurring material that can be utilized as a nuclear explosive. However, not all kinds of uranium can be used to make nuclear weapons. One cannnot use natural uranium (the stuff that is mined), or low-enriched uranium (the stuff that is used as fuel in most commercial power reactors around the world) as a nuclear explosive. The problem with these materials is that there is too much uranium-238 (which is NOT a nuclear explosive) and too little uranium-235 (which IS a nuclear explosive). Uranium enrichment is a technological process for increasing the concentration of uranium-235 by separating out and discarding much of the unwanted uranium-238. The end product of this separation process is called “enriched uranium” — uranium with a higher concentration of U-235 than that found in naturally occurring uranium. The discarded material — mostly uranium-238 — is called “depleted uranium” because it has even less uranium-235 per kilogram than is found in natural uranium ore deposits (0.7 percent). Technically, any type of uranium in which the concentration of uranium-235 is 20 percent or more is called Highly Enriched Uranium (HEU). HEU of any kind can be used as a nuclear explosive material, if available in sufficient quantity. Nuclear weapons designers prefer HEU that is more than 90 percent enriched — i.e. more than 90 percent U-235. Such HEU is called “weapons-grade uranium”. Any type of HEU is weapons-usable, even if it is not weapons-grade. Most commercial power reactors use only Low Enriched Uranium (LEU) as fuel; LEU cannot be used as a nuclear explosive due to the excessive amount of uranium-238 that it contains. It is a slow, difficult, time-consuming process to enrich uranium — but once weapons-grade uranium is produced, it is rather easy to make a powerful atomic bomb with it. All that is needed is a “gun-type” mechanism to bring two pieces of HEU together very rapidly, by firing a uranium “bullet” into a uranium “target”. The Hiroshima bomb was made in this fashion. The gun-type mechanism is so simple there is no need to test it. It was guaranteed to work the very first time it was tried. As indeed it did…. If weapons-grade uranium falls into criminal hands, the construction of a powerful atomic bomb is a relatively simple matter. No testing is needed. That is why the civilian use of HEU is being phased out — it’s just too dangerous to allow this material to remain in commercial circulation. B. Plutonium — Created from Uranium-238 Plutonium does not exist in nature; but it is created inside every reactor that uses natural uranium or low-enriched uranium as fuel. Some of the uranium-238 atoms in the fuel absorb stray neutrons, and those atoms are transmuted into plutonium atoms. It turns out that plutonium is a more powerful nuclear explosive than HEU. Plutonium is in fact more powerful than weapons-grade uranium. Obtaining plutonium involves a chemical extraction process that requires dissolving highly radioactive “used nuclear fuel” in boiling nitric acid — not an easy task! This makes it difficult to divert the plutonium from civilian nuclear reactors into bombs, unless the plutonium has already been extracted ahead of time. Once the plutonium has been separated from the rest of the radioactive garbage, it can be packaged and transported without detection fairly easily. Using plutonium as a nuclear explosive does require a more elaborate bomb mechanism than the “gun-type” uranium bomb design. A sophisticated “implosion mechanism” is needed. That requires the simultaneous detonation of shaped charges (conventional explosives) surrounding a perfectly spherical ball of plutonium. Such an implosion device is by no means simple; it requires painstaking engineering and careful testing. The Nagasaki bomb was made in this fashion. It was tested months ahead of time at Alamogordo, New Mexico. All reactor-produced plutonium is weapons-usable, but nuclear weapons designers prefer to use plutonium with a very high percentage of plutonium-239 and a low percentage of plutonium-240. Such material is called “weapons grade plutonium”. Although plutonium-240 is a nuclear explosive material, its presence complicates the job of the bomb-maker in two ways: (1) it makes the explosive material more difficult to handle because of higher levels of radio- activity and heat; (2) it makes the power of the nuclear explosion less predictable because it produces a lot of stray neutrons. Despite these complications, any type of plutonium can be used to make reliable, highly effective nuclear weapons at all levels of technical sophistication. See http://www.ccnr.org/Findings\_plute.html C. Uranium-233 — Created from Thorium-232 As previously remarked, naturally occurring thorium — thorium-232 — is the raw material from which a new kind of uranium — uranium-233 — can be created. All that’s needed is to bombard thorium-232 with neutrons. The easiest way to do that is to put the thorium inside a nuclear reactor, where neutrons are abundant. (Of course the reactor has to be fuelled by uranium or plutonium, otherwise there will be no neutrons.) When a thorium-232 atom absorbs a stray neutron it is transmuted into an atom of protactinium-233, which then spontaneously transmutes itself into an atom of uranium-233 — a type of uranium not found in nature. It turns out that uranium-233 is immediately weapons usable without the need for any kind of enrichment. It is a more powerful explosive than uranium-235, and — unlike plutonium — it can be used in a simple gun-type device, like the Hiroshima bomb. Thus uranium-233 avoids one of the complications posed by the use of uranium-235 (the need for enrich- ment) as well as one of the complications associated with plutonium (the need for an implosion mechanism). There is however another complication that arises. When thorium is placed inside a nuclear reactor, there is another type of uranium created called uranium-232. Although uranium-232 is also a nuclear explosive material, it is highly undesirable because it gives off an extremely powerful burst of gamma radiation — so powerful, in fact, that it can seriously damage electronic equipment. The more uranium-233 is contaminated with uranium-232 the more difficult it is to use it as a nuclear explosive. But, as the article cited above (see link) points out, it is relatively easy to avoid this contamination problem. All that is required is to chemically separate the protactinium-233 at an early stage, remove it from the reactor environment, and then simply wait until it has almost all changed into uranium-233. In this way a stockpile of weapons-grade uranium-233 can be produced that is uncontaminated with uranium-232 and virtually trouble-free for making any type of nuclear weapon, including gun-type A-bombs. The reason this works is due to the absence of neutrons outside the reactor environment. Uranium-232 is created only in the presence of neutrons, and outside the reactor there aren’t any neutrons — so no uranium-232 is being produced. But protactinium-233 becomes uranium-233 spontaneously, without any need for neutrons. So by separating the protactinium-233 from the rest of the irradiated thorium, the potential bomb-maker gets lots of uranium-233, and virtually no uranium-232.

### prolif

#### Small-scale thorium reactors would make prolif easier—their ev gets the isotope math wrong

**Helian, 10** – Technical contractor with a PhD in nuclear engineering (“Subcritical Thorium Reactors: Dr. Rubbia’s Really Bad Idea,” September 1, Helian Unbound, http://helian.net/blog/2010/09/01/nuclear-weapons/subcritical-thorium-reactors-dr-rubbias-really-bad-idea/)//vivienne

In any case, the design he seems to be so excited about is Dr. Rubbia’s “energy amplifier,” which, as noted above, would be subcritical, requiring a powerful, high current proton accelerator to keep the fission process going. It would do this via spallation, a process in which a copious source of the neutrons required to keep the reaction going would be provided via interaction of the protons with heavy nuclei such as lead, or thorium itself. This is the process used to produce neutrons at the Oak Ridge Spallation Neutron Source. Such reactors could easily be “turned off” by simply shutting down the source of neutrons. However, the idea that they would be inherently “safer” is dangerously inaccurate. In fact, they would be an ideal path to covert acquisition of nuclear weapons. Thorium reactors work by transmuting thorium into U233, which is the isotope that fissions to produce the lion’s share of the energy. It is also an isotope that, like U235 and Pu239, can be used to make nuclear bombs. The article downplays this risk as follows: After the Manhattan Project, US physicists in the late 1940s were tempted by thorium for use in civil reactors. It has a higher neutron yield per neutron absorbed. It does not require isotope separation, a big cost saving. But by then America needed the plutonium residue from uranium to build bombs. “They were really going after the weapons,” said Professor Egil Lillestol, a world authority on the thorium fuel-cycle at CERN. “It is almost impossible make nuclear weapons out of thorium because it is too difficult to handle. It wouldn’t be worth trying.” It emits too many high (energy) gamma rays. What Lillestol is referring to is the fact that, in addition to U233, thorium reactors also produce a certain amount of U232, a highly radioactive isotope of uranium with a half life of 68.9 years whose decay does, indeed, release potentially deadly gamma rays. It would be extremely difficult, if not impossible, to remove it from the U233, and, if enough of it were present, it would certainly complicate the task of building a bomb. The key phrase here is “if enough of it were present.” Thorium enthusiasts like Lillestol never seem to do the math. In fact, as can be seen here, even conventional thorium breeders could be designed to produce U233 sufficiently free of U232 to allow workers to fabricate a weapon without serious danger of receiving a lethal dose of gamma rays. However, large concentrations of highly radioactive fission products would make it very difficult to surreptitiously extract the uranium, and it would also be possible to mix the fuel material with natural or depleted uranium, reducing the isotopic concentration of U233 below that necessary to make a bomb. With subcritical reactors of the type proposed by Rubbia, the problem of making a bomb gets a whole lot easier. Rogue state actors, and even terrorists groups if we “succeed” in coming up with a sufficiently inexpensive design for high energy proton accelerators, could easily modify them to produce virtually pure U233, operating small facilities that it would be next to impossible for international monitors to detect. There are two possible pathways for the production of U232 from thorium, both of which involve a reaction in which a neutron knocks two neutrons out of a heavy nucleus of Th232 or U233. Those reactions can’t occur unless the initial neutron is carrying a lot of energy as can be seen in figure 8 of the article linked above, the threshold is around 6 million electron volts (MeV). That means that, in order to produce virtually pure U233, all that’s necessary is to slow the incoming spallation neutrons below that energy. That’s easily done. Imagine two billiard balls on a table. If you hit one as hard as you can at the other one, what happens when they collide? If your aim was true, the first ball stops, transferring all its energy to the second one. The same thing can be done with neutrons. Pass the source neutrons through a layer of material full of light atoms such as paraffin or heavy water, and they will bounce off the light nuclei, losing energy in the process, until they eventually become “thermalized,” with virtually none of them having energies above 6 MeV. If such low energy neutrons were then passed on to a subcritical core, they would produce U233 with almost no U232 contamination. It gets worse. Unlike Pu239, U233 does not emit a lot of spontaneous neutrons. That means it can be used to make a simple gun-type nuclear weapon with little fear that a stray neutron will cause it to fizzle before optimum criticality is reached. And, by the way, a lot less of it would be needed than would be required for a similar weapon using U235, the fissile material in the bomb that destroyed Hiroshima. We’re quite capable of blowing ourselves up without Rubbia’s subcritical reactors. Let’s not make it any easier than it already is. Thorium reactors have many potential advantages over other potential sources of energy, including wind and solar. However, if we’re going to do thorium, let’s do it right. UPDATE: Steven Den Beste gets it right at Hot Air. His commenters throw out the usual red herrings about the US choosing U235 and Pu239 over U233 in the Manhattan Project (for good reasons that had nothing to do with U233′s suitability as a bomb material) and the grossly exaggerated and misunderstood problem with U232. You don’t have to be a nuclear engineer to see through these fallacious arguments. The relevant information is all out there on the web, it’s not classified, and it can be understood by any bright high school student who takes the time to get the facts.

#### Specifically, thorium requires reprocessing—causes prolif

**Edwards, 11** – PhD and President at the Canadian Coalition for the Nuclear Responsibility (Gordon, “Thorium Reactors: Back to the Dream Factory: The Nuclear Dream Factory,” July 13, Forgotten People, http://forgottennavajopeople.org/2011/07/14/7132011-thorium-reactors-back-to-the-dream-factory-the-nuclear-dream-factory/)//vivienne

Thorium is not a nuclear fuel: The fundamental fact about thorium is that it is NOT a nuclear fuel, because thorium is not a fissile material, meaning that it cannot sustain a nuclear fission chain reaction. In fact the ONLY naturally occurring fissile material is uranium-235, and so — of necessity — that is the material that fuels all of the first-generation reactors in the entire world. Thorium cannot replace uranium-235 in this regard. Not at all. Thorium is a “fertile” material: But thorium-232, which is a naturally occurring radioactive material, is about three times as abundant as uranium-238, which is also a naturally occurring radioactive material. Neither of these materials can be used directly as a nuclear fuel, because they are not “fissile” materials. However, both uranium-238 and thorium-232 are “fertile” materials, which means that IF they are placed in the core of a nuclear reactor (one that is of necessity fuelled by a fissile material), some fraction of those fertile atoms will be transmuted into man-made fissile atoms. Some uranium-238 atoms get transmuted into plutonium-239 atoms, and some thorium-232 atoms get transmuted into uranium-233 atoms. Both plutonium-239 and uranium-233 are fissile materials which are not naturally-occurring. They are both usable as either fuel for nuclear reactors or as nuclear explosive materials for bombs. (The USA exploded an atomic bomb made from U-233 in 1955.) Reprocessing of irradiated nuclear fuel: In general, to obtain quantities of plutonium-239 or uranium-233, it is necessary to “reprocess” the irradiated material that started out as uranium-238 or thorium-232. This means dissolving that irradiated material in acid and then chemically separating out the fissile plutonium-239 or uranium-233, leaving behind the liquid radioactive wastes which include fission products (broken pieces of split atoms, including such things as iodine-131, cesium-137, strontium-90, etc.) and other radioactive waste materials called “activation products” and “transuranic elements” Reprocessing is the dirtiest process in the entire nuclear fuel chain, because of the gaseous radioactive releases, liquid radioactive discharges, and large quantities of highly dangerous and easily dispersible radioactive liquids. Reprocessing also poses great proliferation risks because it produces man-made fissile materials which can be incorporated into nuclear weapons of various kinds by anyone who acquires the separated fissile material. Advanced Fuel Cycles and Breeders: “Any nuclear reactor-fuelling regime that requires reprocessing, or that uses plutonium-239 or uranium-233 as a primary reactor fuel, is called an “advanced fuel cycle”. These advanced fuel cycles are intimately related with the idea of a “breeder” reactor — one which creates as much or more fissile material as a byproduct than the amount of fissile material used to fuel the reactor. So it is only in this context that thorium reactors make any sense at all — like all breeder concepts, they are designed to extend the fuel supply of nuclear reactors and thus prolong the nuclear age by centuries. The breeder concept is very attractive to those who envisage a virtually limitless future for nuclear reactors, because the naturally occurring uranium-235 supply is not going to outlast the oil supply. Without advanced fuel cycles, nuclear power is doomed to be just a “flash in the pan”. Thorium reactors are most enthusiastically promoted by those who see “plutonium breeders” as the only other realistic alternative to bring about a long-lived nuclear future. They think that thorium/uranium-233 is a better fate than uranium/plutonium-239. They do not see a nuclear phaseout as even remotely feasible or attractive. “Molten Salt” reactors : Molten salt reactors are not a new idea, and they do not in any way require the use of thorium — although historically the two concepts have often been linked. The basic idea of using molten salt instead of water (light or heavy water) as a coolant has a number of distinct advantages, chief of which is the ability to achieve much higher temperatures (650 deg. C instead of 300 deg. C) than with water cooled reactors, and at a much lower vapour pressure. The higher temperature means greater efficiency in converting the heat into electricity, and the lower pressure means less likelihood of an over-pressure rupture of pipes, and less drastic consequences of such ruptures if and when they do occur. Molten salt reactors were researched at Oak Ridge Tennessee throughout the 1960s, culminating in the Molten Salt Reactor Experiment (MSRE), producing 7.4 megawatts of heat but no electricity. It was an early prototype of a thorium breeder reactor, using uranium and plutonium as fuels but not using the thorium blanket which would have been used to “breed” uranium-233 to be recovered through reprocessing — the ultimate intention of the design. This Oak Ridge work culminated in the period from 1970-76 in a design for a Molten Salt Breeder Reactor (MSBR) using thorium as a “fertile material” to breed “fissile” uranium-233, which would be extracted using a reprocessing facility. Molten Salt Thorium reactors without reprocessing?: Although it is theoretically possible to imagine a molten-salt reactor design where the thorium-produced uranium-233 is immediately used as a reactor fuel without any actual reprocessing, such reactor designs are very inefficient in the “breeding” capacity and pose financial disincentives of a serious nature to any would-be developer. No one has actually built such a reactor or has plans to build such a reactor because it just isn’t worth it compared with those designs which have a reprocessing facility. Here’s what Wikipedia says on this matter (it happens to be good info): http://en.wikipedia.org/wiki/Molten\_salt\_reactor To exploit the molten salt reactor’s breeding potential to the fullest, the reactor must be co-located with a reprocessing facility. Nuclear reprocessing does not occur in the U.S. because no commercial provider is willing to undertake it. The regulatory risk and associated costs are very great because the regulatory regime has varied dramatically in different administrations. [20] UK, France, Japan, Russia and India currently operate some form of fuel reprocessing. Some U.S. Administration departments have feared that fuel reprocessing in any form could pave the way to the plutonium economy with its associated proliferation dangers.[21] A similar argument led to the shutdown of the Integral Fast Reactor project in 1994.[22] The proliferation risk for a thorium fuel cycle stems from the potential separation of uranium-233, which might be used in nuclear weapons, though only with considerable difficulty. Currently the Japanese are working on a 100-200 MWe molten salt thorium breeder reactor, using technologies similar to those used at Oak Ridge, but the Japanese project seems to lack funding. Thorium reactors do not eliminate problems: The bottom line is this. Thorium reactors still produce high-level radioactive waste, they still pose problems and opportunities for the proliferation of nuclear weapons, they still pose catastrophic accident scenarios as potential targets for terrorist or military attack, for example.

#### Thorium reactors make prolif easier—don’t need to enrich them

**Beste, 10** – reporter for Hot Air (Steven Den, “Nuclear Weapons for the Masses!” Hot Air Blog, August 31, http://hotair.com/greenroom/archives/2010/08/31/nuclear-weapons-for-the-masses/)//vivienne

Glenn Reynolds tends to get hyped on certain kinds of high-tech. His latest “faster please” is thorium reactors. And yeah, there’s a lot to like about them. But there’s a really huge gotcha which is enough to kill the idea stone dead. Thorium reactors use natural thorium, which is isotope 232. There are a lot of neutrons running around in there; it’s how reactors work. If an atom of thorium 232 absorbs a neutron, it becomes isotope 233. Some will fission, but some won’t. Thorium 233 beta decays (HL 22 minutes) to proactinium 233, which beta decays (HL 27 days) to uranium 233. Uranium 233 is fissionable, and you can make bombs out of it. And the best part of all is that it can be purified chemically out of the spent fuel of the thorium reactor. You don’t have to mess around with gas diffusion or centrifuges. If, as some propose, there’s a thorium reactor buried in every backyard, you could face the possibility of pretty much any dedicated extremist being able to build nuclear weapons.